METALLURGIA

THE BRITISH JOURNAL OF METALS

INCORPORATING THE "METALLURGICAL ENGINEER."

APRIL, 1951 Vol. XLIII No. 258

Britain's National Economy

WHEN discussing this country's economy in this journal about a year ago, it was stated that the balance of payments remained the main economic problem during 1950 and would probably do so for many years to come. In 1950, however, as emphasised in the recently published *Economic Survey*, the United Kingdom achieved a balance of payments position; in fact it showed a surplus of £229 million. In making a proper assessment of this change it must also be emphasised that stocks of food and raw materials were considerably reduced during 1950, largely because of efforts to buy in sterling rather than dollar areas; had stocks been maintained, or increased, as might have been anticipated in view of the difficult international situation, last year's surplus would have been substantially smaller. With the imposition of a major rearmament effort, involving increased imports of raw materials, the overall balance of payments of this country is likely to be unfavourable, particularly as world supplies of many commodities are limited and prices are rising. In addition, the emergence of shortages reacts on production and on the supply of goods and machinery for export. We maintain, therefore, that the balance of payments is still the main economic problem of this country and any profound set-back would threaten the place of sterling in the world's markets.

The need for rearmament, however, is real enough. Events in Korea and elsewhere have shown that there is no alternative, if Britain is to safeguard her security and the independence of her people, and the Government is justified in making a greatly enlarged and accelerated rearmament programme the first objective in its economic policy. The efforts to satisfy it, however, will react adversely on all other activities and the economic prospects for 1951, as stated in the *Survey*, are unpleasant. The assumptions upon which the *Survey* is based may well prove to be optimistic. For instance, it is assumed there will be a 4% increase in industrial production, but the question of sufficient raw materials to enable the achievement of this increase arises; the raising of earnings from visible exports by £500 million cannot be counted on, nor can the rise in import prices be kept within the limits specified. Everyone knows, from hard experience, that productive work is the only sort that really matters, but comparisons of one year with another on the basis of monetary values are ceasing to have any significance because the basis is changing so rapidly.

The direct burden of production for defence falls mainly on the metal-using industries. In 1950 these industries produced goods valued at about £2,400 million, providing about two-fifths of the country's exports and the great bulk of the plant and machinery for home investment. Of their total output last year about two-fifths was exported, just over one-third was used for home investment, and the remainder was divided between defence, consumption, and other home uses. The rearmament programme will place a new demand on these industries at a time when shortages of materials must hamper further growth of their production. Recent increases in production have been made possible largely as a result of the freer flow of raw materials. Supplies of ferrous and non-ferrous metals will act as effective limits to output in 1951, and, in the light of what is known about these supplies, there seems to be no hope of production increasing by anything like as much as last year.

The iron and steel industry exceeded its production target of 15·75 to 16 million tons for 1950, the output of steel ingots and castings being 16·29 million tons. Capacity will increase during 1951 and it is estimated that 16·75 million tons of steel could be produced if full supplies of raw materials could be depended upon. Unfortunately, supplies of raw materials, particularly scrap iron and steel, are not likely to be adequate to keep capacity fully employed and it is considered unwise to expect production to exceed 16 to 16·25 million tons; even this may prove to be an optimistic forecast. Much depends on scrap imports and especially on the success of the drive to recover home-produced scrap. Difficulties may arise over the supply of certain types of alloy steel. The production of sheet and tinplate, which is at present in short supply, will be greatly augmented by the new mills at Margam and Trostre which are expected to be in operation during the latter half of this year.

Several of the non-ferrous metals are scarce at the present time, the most serious shortage being that of zinc, but copper is also scarce, as are supplies of aluminium and nickel. Supplies of zinc and copper are not expected to reach last year's levels and rationing schemes have already been introduced. Fortunately, with regard to aluminium, a long-term contract has been negotiated with Canadian producers which will secure an additional 50,000 tons of the metal in the second half of this year, making 200,000 tons for the year as a whole, and an annual supply of 220,000 tons in 1952 and 1953.

While the raw material position will create difficulties in maintaining the 1950 rate of production, significant changes in the pattern of output in the metal-consuming industries will have to take place. A considerable part of the new arms production will be provided by firms whose capacity is already fully employed. In many cases, such firms will need to defer work on other orders so that they can carry out more urgent defence work. Double or treble shift working is suggested to be undertaken where necessary. Since practically no labour is available, apart from that engaged on production for export or home use, rearmament will cut production for export and as the programme proceeds this change will become increasingly serious to national economy. Many steps have been taken to curtail home supplies in order to maintain exports, an outstanding example

being a reduction in the allocation of new cars to the home market from 110,000 in 1950 to 80,000 in 1951. Probably the most effective of these steps is indicated in the budget, some details of which have just come to hand at the time of writing, which shows considerable increases in purchase tax, which are intended to discourage people from buying goods which will be in short supply.

There is nothing in this *Survey* to inspire industry to meet the new burdens which will grow in intensity, but relatively only the fringe of the programme will be felt this year; it is during next year and 1953 that the full impact of these burdens will be felt and whether the steps taken to safeguard the nation's economy are really adequate remains to be seen. Meanwhile, industry will need to accept with patience the shortages and high prices and do everything possible to eliminate waste and inefficiency. If we could be as sure that the Government would also eliminate waste and inefficiency it would greatly assist the task the new burdens place on the country as a whole.

U.K. Lead-Zinc Mining Revival

PRESENT-DAY conditions have resulted in a revival of Britain's lead and zinc mining industry, which had gradually declined after its prosperous days in the latter half of last century. In an article in a recent issue of *The Financial Times*, an interesting review of the present position of the industry was given.

During the past 18 months mining companies have been carrying out geological tests and surveys in various parts of the British Isles, including North Wales, Derbyshire and Southern Ireland, and the deposits found have in some cases encouraged the companies to begin mining operations. The main areas where reserves of ore are known to exist are in the Northern Pennines, Derbyshire and North Wales. In the Pennines there are areas where the Great Limestone, which is favourable for ore deposition, is accessible but not fully explored. 100,000 tons of ore is said to be situated near Middleton-in-Teesdale, and at East Allendale a reserve of ore has been indicated on the continuation of the Esps vein.

Behind a great deal of present activity is the Johannesburg Consolidated Investment Trust, the South African mining finance house. This company, after much research, has decided to lay out considerable capital on the development of lead and zinc mining. One of its interests is at Llanrwst, in Denbighshire, where it has reopened the Parc mine. The company's mining experts consider there are sufficient ore reserves to keep this mine working for 20 years. Output is already under way and it is hoped that by June, production will have reached 200 tons of lead-zinc ores daily. The company also has interest in a Southern Ireland mine which it is working in conjunction with the Abbey Town Mining Company of Dublin. Daily production is now around 100 tons of lead-zinc ores. Further development may be expected at Matlock, in Derbyshire, where the South African company is investigating deposits in collaboration with Derbyshire Stone; the latter company is already producing a small amount of lead as a by-product of its main function of fluorspar mining.

Another mine which should be operating shortly is the Trecastell mine, near Conway, which was closed in 1921 as uneconomic. The Ministry of Supply granted a licence for working the lead and zinc deposits last December after the Trecastell Lead Mines Company had spent two years in surveying. Production should start in about four months and it is planned to reach an output of about 65 tons of ore daily.

The extraction ratio of the mined ore is usually about eight per cent., roughly in equal proportions of lead and zinc. But before it goes to the smelter the ore has to pass through various processes, and the final concentrate value in metal content is 70 to 80 per cent. of the extraction for lead and 50–60 per cent. for zinc.

Based on these approximate values the output of metal for these three revitalised mines would be 3,200 tons of lead and 2,100 tons of zinc each year. This would about double U.K. production of lead and more than quadruple zinc output. Even so it would still represent only a tiny fraction of total home consumption of these metals, which last year was 163,000 tons of lead and 220,000 tons of zinc.

The other main producing centres for lead-zinc ores are the Halkyn Mine, near Holywell, Flintshire; Greenside Mine in Westmorland; and Nentsbury Mine at Alston, Cumberland. The first-named has been working almost continuously for many years, but even now is occasionally finding new deposits. At Greenside it is estimated that reserves are sufficient for another four years working.

In most cases the ore is mined from underground levels, and to get an old mine operating again is an expensive proposition. The survey of the site and analysis of deposits would alone require many hundreds of pounds and might show no return at all. Considerable outlay would be necessary in de-watering the old workings; and new shafting and equipment would almost certainly be necessary. In round figures the total expenditure, including labour costs, could be all of £500,000.

Where deposits are found on hillsides—this has been the case in one area in North Wales—the mining process is much easier and less costly because no shafting is required and the de-watering problem is simplified. The ore is extracted by tunnelling—known as the adit method. To put a hillside mine into operation would probably cost about £200,000.

By and large the development of an old mine or of new deposits can only be regarded as highly speculative. And therein, no doubt, lies one of the reasons why the Government, despite the need for these metals for the defence programme, has so far given no financial blessing to any mining projects.

The companies involved in the industry are conducting operations at a level of costs which would still leave a margin of profit should prices fall from their present high levels. One company states that it will be able to continue profitable working even if the price of lead and zinc drops by as much as 50 per cent.

The Royal Aeronautical Society

THE Society's Annual Garden Party will be held on Sunday, May 6th, 1951, at White Waltham Aerodrome, near Maidenhead. This year the signal for the opening of the Garden Party will be made by the arrival of the President and his wife by helicopter.

The Society's Garden Party is the first Flying Party of the Festival of Britain Year. An attractive programme of flying events is being prepared and a special Souvenir printed programme will be available to those attending the Party. Tickets for the Garden Party are limited to members and their guests.

The Importance of Silicon in Niobium-Bearing Steels and Alloys

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A ternary iron-niobium silicide, with an approximate formula $Fe_4\ Nb_5\ Si_3$, has been found by X-ray analysis in extracts from niobium-bearing austenitic heat-resisting steels and in silicon-rich ferro-niobium. With the aid of this information, it is possible to explain satisfactorily the constitution of such steels as a collection of carbides, silicides and intermetallic compounds (iron-niobides and tungstides) in an austenitic matrix, and to construct a tentative Fe-Nb-Si diagram. In heat-resisting alloys containing niobium (and probably also the other Group IV and V elements), silicon plays, therefore, a role comparable in importance with that of carbon; to some extent, the silicide and carbide-forming tendencies are competitive. The formation of the silicide, or its elimination, may be critically controlled by slight changes in the balance of the alloying elements (e.g., Nb/Si ratio), as well as by heat-treatment.

THE need for materials possessing good heat- and creep-resisting properties, for use in gas turbines, has given rise to the development of the niobium-bearing austenitic steels of the now well-known G18B and R20 types (Oliver and Harris[1,2,3]), which made it possible for the first time to obtain satisfactory service from industrial gas-turbine rotor and blade materials operating at temperatures of 700° C.

During the development of G18B and R20 at Messrs. Wm. Jessop & Sons, Ltd., the study of phase-constitution by X-ray analysis formed an integral part of the investigations. This study yielded results believed to be of interest on a wider scale than the present limited problem would suggest, throwing light as they do on carbide and compound formation in alloy steels generally. The present paper is intended briefly to report on the important role silicon appears to be playing, while a brief account on the general phase-constitution (partly outlined by Oliver and Harris[1]) will be published separately.

Experimental

The types of sample used for X-ray analysis were :—

(*a*) the unextracted bulk-steel (mainly for the study of the matrix constitution and lattice dimensions),

(*b*) electrolytic extracts.

This paper concerns the results obtained on the electrolytic extracts, a procedure which is always necessary to render weak phases visible. The technique employed was the normal powder photography method, using 9 or 19 cm. diameter cameras with Co K_α (sometimes Mn K_α) radiation. Phase identification was carried out visually and from interplanar spacings and photometer records, information on carbide and other standards having been assembled from previous work.[4,5,6] The patterns produced were, however, of a highly complex character, and could not be completely accounted for by the previously known carbides and intermetallic compounds.

The chemical compositions of G18B and R20 steels are shown in Table I, as representative of a number of other steels examined.

TABLE I.—COMPOSITION OF G18B AND R20 STEELS.[2] (WEIGHT %).

	G18B	R20
Carbon	0·4	0·14
Manganese	0·8	0·8
Silicon	1·0	0·3
Nickel	13·0	14·0
Chromium	13·0	19·0
Cobalt	10·0	—
Tungsten	2·5	—
Molybdenum	2·0	—
Niobium	3·0	1·7

It was impracticable to explore the phase-constitution of the ten-component system Fe-Ni-Cr-W-Mo-Nb-Co-Mn-Si-C by synthetic alloys, and as the solution of the problem was urgent, short-cut methods had to be adopted. Considerable help was derived here from commercial ferro-alloys of different known analyses, namely ferro-niobium and ferro-tungsten, as well as from a series of steels chosen for their systematic variation in added elements.

The Phase-Constitution

In the electrolytic residues extracted from heat-resisting steels, carbides form, of course, the major portion; in the case of the older (no-Nb) 18/8 or 13/13 type Cr-Ni austenitic steels this is chiefly the chromium base κ carbide $(Cr, Fe)_{23}\,C_6$. Added tungsten and molybdenum first enter into the κ solid solution; but, beyond a limited amount, stabilise the η -carbide, $Fe_4(W,Mo)_2\,C$, so prominent in high speed steels. In the presence of niobium (and for that matter vanadium and titanium), stable carbides of the sodium chloride type of structure are formed, viz. NbC/Nb_4C_3(*), VC/V_4C_3 and TiC, so that in the present niobium-bearing steels, NbC is generally observed prominently (cube-edge a_o = 4·4404kX). However, an additional pattern appeared in some of the extracts, thought to correspond to an iron-niobide. This agreed well with that of a compound prominent in ferro-niobium, but, as will be shown presently, *silicon* forms an essential part in it.

Ferro-niobium

Among a number of types of commercial grades of

[1] Oliver and Harris, *Jnl. West Scot. Iron and Steel Inst.*, 1946–47, **54**, p. 97.
[2] Oliver and Harris, *Trans. Inst. Marine Engs.*, 1947, **59**, p. 79.
[3] Oliver and Harris, *Iron and Steel*, 1946, **19**, p. 379.
[4] Goldschmidt, *Jnl. Iron and Steel Inst.*, 1948, **160**, p. 345.
[5] Goldschmidt, *Nature*, 1948, **162**, p. 855.
[6] Goldschmidt, *Metallurgia*, 1949, **40**, p. 96.

* NbC and VC form defect lattices by omission of interstitial carbon, so as to assume compositions Nb_4C_3 and V_4C_3.

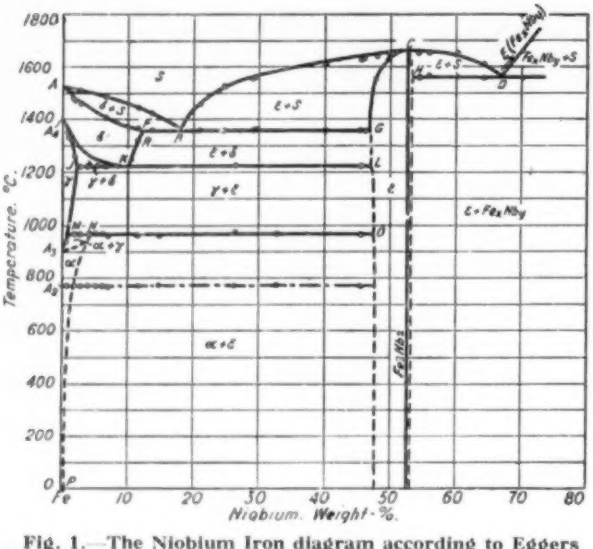


Fig. 1.—The Niobium Iron diagram according to Eggers and Peter.

ferro-niobium available, two differed greatly in silicon content as will be seen from Table II.

The X-ray diffraction patterns of the two types of ferro-niobium were very different, *a* containing two iron niobides, denoted ϵ and ν, and known in the iron-niobium binary system, whilst the pattern for *b* indicated the presence of a new compound.

The binary system Fe-Nb has been examined by Genders and Harrison,[7] and by Vogel and Ergang.[8] The diagram according to Eggers and Peter[9] is reproduced in Fig. 1, from which it will be seen that two compounds occur, Fe_3Nb_2 (ϵ) and $Fe_x Nb_y$ (ν), rich in niobium but of uncertain composition. From the composition of alloy *a*, and the fact that it consists mainly of ν plus a small amount of ϵ, the formula of $Fe_x Nb_y$ is tentatively placed at approximately $Fe Nb_2$ (78 wt.% Nb). The formula for ϵ was later modified by Peter[10] to Fe_2Nb, but there is evidence supporting Fe_3Nb_2 as more probably correct; a limited solid solution range of Fe_3Nb_2 for iron, as in the case of Fe_3Mo_2 and Fe_3W_2 is, however, likely to exist.

Two experimental steels were also available, containing, respectively, 5 and 15% Nb; the analyses (wt. %) were :—

	Steel *A*	Steel *B*
Carbon	0·41	0·51
Manganese	0·52	0·70
Silicon	0·70	1·04
Niobium	5	15

In both cases the phase constitution was :

A new phase ϕ + NbC + ferrite, where ϕ increases greatly from *A* to *B*.

The important point, however, is that, firstly, this phase ϕ agrees with that observed in ferro-niobium *b*, i.e. the silicon-rich type, and, secondly, it accounts for phases observed in G18B and associated steel extracts, all of which were high in silicon.

TABLE II.—COMPOSITION OF FERRO-NIOBIUM. (WEIGHT %).

	Type *a*	Type *b*
Carbon	0·10	0·31
Silicon	0·93	5·86
Iron	27·60	29·90
Niobium	57·70	55·60
Tantalum*	9·17	3·60
Tungsten	3·96	4·12
Titanium	0·60	0·30

* Tantalum, for the present purpose, may be considered on an atom substitution basis as equivalent to niobium.

TABLE III.—INTERPLANAR SPACINGS OF IRON-NIOBIUM SILICIDE ϕ (kx)

2·84 w	1·83 w	1·425 mw	1·083 w(?)
2·40 sm	1·76 vw	1·385 m	1·066 sm
2·21 s	1·56 w	1·236 w	1·035 m
1·97 w	1·473 m	1·110 mw	0·962 m

(Intensities :—s = Strong; sm = Strong/medium; m = Medium; mw = Medium/weak; w = Weak vw = Very Weak).

Table III shows the interplanar spacings of the ϕ-phase, as obtained from steel *B* and ferro-niobium *b*. The latter contains some iron-niobide Fe_3Nb_2, which agrees with the subsidiary phase in ferro-niobium *a*. Fig. 2 shows relevant powder photographs in illustration.

Nature of Phase ϕ

The above evidence strongly indicates that the phase is an iron-niobium silicide, and from the following considerations it is possible to deduce its approximate composition. A small amount of ferrite is observed in the silicon-rich ferro-niobium, sample *b*, preserved on prolonged annealing at 1000° C., and absent from the silicon-poor alloy *a*. Thus the alloy *b* demarcates the ϕ-rich end of a two-phase-field α-Fe + ϕ, near the α-rich end of which lie the steels *A* and *B* (though in the adjoining α + ϕ + NbC three-phase triangle). The ϕ compound must, from the proportions of ϕ and α, be situated very near to alloy *b* and in continuation of the tie-line directed towards α. From the data available it is possible to derive a very approximate phase-diagram Fe-Nb-Si, shown in Fig. 3, (applying to a low-temperature

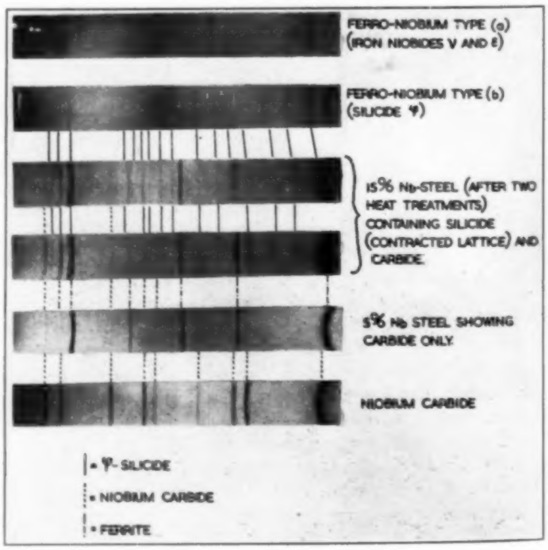


Fig. 2.—X-ray powder photographs relevant to the iron-niobium silicide.

7 Genders and Harrison, *Jnl. Iron and Steel Inst.*, 1939, **140**, p. 29.
8 Vogel and Ergang, *Arch. Eisenhuttenwes*, 1938, **12**, p. 155. *Metallurgist*, 1938, **11**, p. 164.
9 Eggers and Peter, *Mitt. Kais. Wilh. Inst. Eisenf.*, 1938, **20**, p. 199.
10 Peter, *Arch. Eisenhuttenwes*, 1942, **15**, p. 363.

equilibrium). It is emphasised that this is tentative only, and that, strictly, the available alloys lie, of course, in multi-component systems ; the diagram has been drawn on the understanding that it is regarded as mainly one of principle, to serve as a basis for discussion*. The phase-assemblies occurring are :—

Single-phase — α (ferrite), ϵ, ν, ϕ ;
Two-phase — $\alpha+\epsilon$, $\epsilon+\nu$, $\alpha+\phi$, $\epsilon+\phi$, $\nu+\phi$;
Three-phase — $\alpha+\epsilon+\phi$, $\epsilon+\phi+\nu$.

The atomic composition of ϕ can be calculated as corresponding to the approximate formula $Fe_4Nb_5Si_3$; but lattice-spacing variations amongst different ϕ-containing samples, show that an appreciable solid solution field exists, probably not only within the Fe-Nb-Si plane, but also in regard to solubility for other elements, e.g. molybdenum and tungsten. The diagram shows how readily a phase boundary can be crossed by a slight alteration in composition and how, for example, a small change in the Si/Nb ratio may be critical in introducing or eliminating the silicide and/or the two iron-niobides.

Effect of tungsten

In the iron-tungsten system (discussed separately[11]) the intermetallic compound $\xi = Fe_3W_2$ occurs ; this is readily available in almost pure form in certain grades of commercial ferro-tungsten. Interdiffusion tests on powdered mixtures of ferro-niobium and ferro-tungsten showed that Fe_3Nb_2–Fe_3W_2 effectively forms a quasi-binary system, in which limited mutual solid solutions of the end-members occur, as well as an intermediate phase (ϵ') of composition $Fe_3(Nb,W)_2$; the latter is structurally closely related to Fe_3Nb_2, but a distortion is shown by definite anomalies in line positions and intensities. In the presence of tungsten beyond the amount soluble in ϵ, the ϕ-silicide is liable to form in succession, equilibria with (1) ϵ, (2) ϵ', (3) ξ, phase assemblies which must be considered as fundamental in our niobium-bearing steels. Addition of carbon has the effect of successively stabilising (1) NbC, (2) the κ-carbide $Fe_{21}(W,Nb)_2C_6$, and (3) the η-carbide Fe_4W_2C/Fe_3W_3C.

* The detailed Fe-Nb-Si system is at present being investigated by the author.
11 Goldschmidt, (not yet published).

TABLE IV.—ANALYSIS OF STEEL AND RESIDUE (G18B, AS ANNEALED 700° C.). (WEIGHT %).

	Steel.	Residue.	Ratio. (Gain or Loss on extraction)
Carbon	0·40	4·00	10
Silicon	1·38	5·75	4
Iron	52·68	22·10	0·4
Niobium Tantalum ..	2·80	27·30	10
Chromium	13·50	14·67	1·1
Tungsten	2·42	16·81	7
Molybdenum	1·83	9·53	5
Manganese	0·89	—	—
Nickel	13·50	Nil	0
Cobalt	10·60	Nil	0

TABLE V.—CONSTITUTION OF G18B STEEL.

	As quenched 1340° C.	As annealed 700° C.
Matrix	Austenite	Austenite
Carbides	NbC/Nb_4C_3	NbC/Nb_4C, $(Cr,Fe,W,Mo)_{23}C_6(\kappa)$ $Fe_4(W,Mo)_2C/Fe_3(W,Mo)_3C(\eta)$
Silicide	Possibly a high temperature form of ϕ	(Approx.) $Fe_4Nb_5Si_3(\phi)$
Inter-metallic compounds	—	Fe_xNb_y (ν, probably x = 1, y = 2) $Fe_3(W,Mo)_2$ (ξ)
		Potential precipitants are also : Fe_3Nb_2 (ϵ) and $Fe_3(Nb,W,Mo)_2$ (ϵ').

The silicide as steel constituent

The ϕ-silicide occurs not only in steels *A* and *B*, and in ferro-niobium as above, but also in electrolytic extracts from G18B and associated steels. The analysis of a residue and of its parent steel (held at 700° C. for 1600 hrs. in a creep test, a treatment which should have precipitated all phases capable of doing so for equilibrium at this temperature) is shown in Table IV.

The phase constitution of G18B steel is highly complex, but could be fully solved from the X-ray photographs, with the result that the phases precipitating are as shown in Table V. In contrast, at high temperatures (as quenched from 1340° C.) all these phases have gone into solution in austenite, with the exception of the niobium carbide, and possibly some ϕ of, however, a modified form.

A trace of undissolved austenite is still present in the extract, which is of considerable incidental interest, as it may well be interpreted as the " austenite-like " -ψ carbide observed elsewhere.[5]

Silicide-formation is corroborated in Table IV by the greatly increased silicon-content on extraction, for which

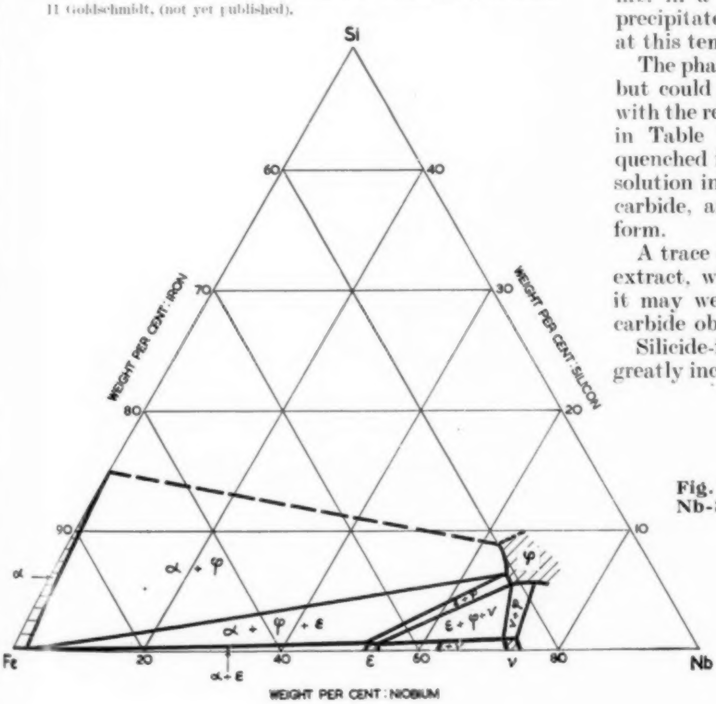


Fig. 3.—Tentative ternary diagram for the Fe-Nb-Si system. (Silicon content on double scale.)

Phases : α—ferrite solid solution.
ϵ—Fe_3Nb_2.
ν—Fe_xNb_y (probably $FeNb_2$).
ϕ—silicide ($Fe_4Nb_5Si_3$ approx.)

the ϕ-phase will be responsible ; the additional presence of silicon, partly as amorphous silica or as a highly dispersed chromium or molybdenum silicide, cannot however be excluded. It may be noted that the silicon-content in ferro-niobium sample *b* and in the above extract are very similar (5·75 and 5·86% Si), and while the analysed carbon, tungsten, molybdenum and chromium, are accounted for by the observed carbides and inter-metallic phases, much of the niobium and iron are tied to the silicon. Furthermore, amongst the residues from five heat-resisting steels, three showed the ϕ-phase and two did not, and it is no coincidence that the three were the niobium-bearing steels, and that the other two did not contain niobium. The gain on extraction in carbon, silicon, niobium, tungsten and molybdenum (Table IV) is consistent with the phase assemblies (Table V) ; nickel and cobalt as matrix elements are lost throughout, while chromium is, characteristically, a borderline element, being partitioned between carbides and matrix and liable to increase or decrease on extraction, depending on heat-treatment and the remaining balance of elements. The considerable amount of iron left is clearly found to dwell in the ϕ-silicide, the η-and κ-carbides, and the intermetallic compounds.

Considering the Fe-Nb-Si diagram (Fig. 3), it is of interest that in the extracts the niobium-rich ν-phase can be in equilibrium with austenite and ϕ, cutting out ϵ. The effect of additional metals (chromium, etc.) has thus been one of eliminating ϵ from equilibrium with the matrix, but with reduced niobium, and other changes in the balance of elements, ϵ and ϵ' are liable to appear.

Formation of further silicides

The ϕ-phase is not the only silicide observed in the niobium-bearing heat-resisting steels ; at least one further iron-niobium silicide has been found prominently for some compositions, of a structure closely resembling ϕ but not identical with it. The phase probably represents a distorted ϕ-lattice, caused by the entry of chromium and alloying elements other than iron.

Sigma-Phase

It is noted that the σ-phase has not been observed in the G18B type of alloys. This contrasts with Binder's valuable recent paper[12] on niobium-bearing heat-resisting steels, in which σ-phase was recorded, as well as NbC, our κ and η carbides and Fe_3Nb_2. His steels were, however, much lower in carbon (less than 0·1%C), higher in chromium (18 to 20% Cr) and lower in silicon (approx. 0·6% Si) than the present ones, in which case σ-formation is quite consistent with phase-diagram relationships. No silicides are reported by Binder. In passing, it may be noted that here again is an example of alternative formation of the σ-and the ξ-structures, a basic feature discussed in connection with the Fe-Cr-W and Fe-Cr-Mo systems[13], but applying extensively to heat-resisting alloys.

ϕ as embrittling arc-weld constituent

A recent direct application of the knowledge of the ϕ-silicide occurred in the work by the writer's colleagues —Bishop and Bailey[14]—on the development of electrode materials for welding austenitic steels. In welding the niobium-bearing R20 steel, trouble was experienced through the formation of " microcracks," a problem also left unsolved in extensive American work. This was traced to the formation of our silicide ϕ as an inter-granular constituent, so that, clearly, excess silicon was one responsible factor ; the strict control of this element to below 0·3% helped to solve the problem of micro-cracking and to evolve a very satisfactory R20 steel welding electrode.

Conclusion and General Note

It may be concluded that the carbide and silicide-forming tendencies of niobium are competitive in character. It would also appear, from the steels and alloys examined, that the niobium shows, in conjunction with iron, an even greater affinity for silicon than for carbon, the partition depending critically on the proportion of other metals present. (For instance, one steel quite low in niobium (0·3%) contained no NbC, but the ϕ-phase and η-carbide in appreciable amounts, showing that, what little niobium there was, had first combined with the silicon, leaving the carbon to combine with the tungsten, molybdenum, etc.).

It is highly probable that niobium is not an isolated element encouraging silicide formation, but that the other Group IV and V elements (V, Ta, Ti, Zr, Hf) will act in a similar manner ; a molybdenum silicide should also be considered.

The chief object of this paper is to draw attention to silicon as an element of comparable importance with carbon in high temperature steels, and to the need for investigating the basic silicide as well as carbide systems. On a broader plane, it may even be suggested that on the substitution of silicon for carbon, a " silicide metallurgy " may develop which stands in a similar relation to carbide metallurgy as silicone chemistry does to the older organic chemistry.

This applies not only to heat-resisting steels and alloys (and of course the established silicon-bearing transformer and structural steels and cast irons), but also to the use of silicides, for example, as raw materials in hard metals in conjunction with, or in replacement of, carbides. The practical value of silicon would lie firstly, in the inherent hardness of silicides, although like carbides they are brittle ; secondly, in their potential function of hardening the matrix when in incipient precipitation ; thirdly, in their ability to produce a thin protective surface-film of silica or silicates which becomes operative especially at high temperatures ; and, lastly, in their greater resistance to atmospheres under which carbides might have suffered decarburization.

Acknowledgment

The author wishes to thank Mr. D. A. Oliver, Director of Research, B.S.A. Group of Companies for his interest and encouragement and Mr. G. T. Harris, Research Manager, Messrs. Wm. Jessop & Sons, Ltd., for his help and advice. The chemical analyses were carried out by Mr. E. W. Harpham.

12 Binder, Trans. *A.S.T.M.*, 1950, Preprint 44.
13 Goldschmidt, Symposium on High Temperature Materials for Gas Turbines, Iron and Steel Inst., Feb., 1951, p. 249.
14 Bishop and Bailey, *Ibid.*, p. 225.

Large Capacity Coal Drying Plant

The British Electricity Authority have placed an order for coal drying plant with the British Rema Manufacturing Co., Ltd., subsidiary of Edgar Allen & Co., Ltd., Imperial Steel Works, Sheffield, 9. The contract, which is of a value in excess of £100,000, covers the complete supply of the plant with buildings and auxiliaries, at Tir John Power Station, Swansea. Anthracite duff and steam duff will be dealt with at the rate of 100 tons per hour, in four British Rema rapid pneumatic dryers.

Production and Metallurgical Characteristics of Mining Hollow Drill Steel in Australia*

By Daniel Clark, F.I.M.

In the first part of this article, which was published last month, the author reviewed the historical aspects of the change from solid to hollow drill steel, including the developments in hollow drill steel manufacture, and concluded with an account of present day practice up to the rolling stage. He now discusses heat treatment and the types of failure encountered in service.

IN the first part of this article, an account was presented of the method of rolling hollow drill steel, an austenitic steel core being inserted into a hole drilled into the billet before rolling. After completion of rolling, the core is removed and the bars are straightened, inspected and oiled to retard rusting during transit and storage. The successful operation of the drill is dependent on the heat treatment being properly carried out and some of the factors concerned in the manufacture of drills from the rolled hollow bars will now be considered.

Heat Treatment

Preliminary Tests for Hardenability

To ensure and provide for reasonable uniformity in heat treatment conditions at the mines, the acceptable analysis of the casts to be rolled into mining drill steel is kept within fairly closely defined limits by a stringent chemical check before being certified as satisfactory. The chemical limits prescribed have been born out of experience and are related to the hardness expectancy following effective and appropriate heat treatment.

Whilst carbon drill steel is a water hardening steel, i.e., one which by heating to a point just above the upper critical range and quenching in water attains the full hardness required for the successful operation of the bits, the composition is such as renders it only borderline when subjected to oil quenching, the normal hardening method employed for heat treatment of the shank. Therefore, it is imperative that only heats which respond to the rather restricted range of hardness obtainable by oil quenching are processed into drill bar, so that the two-fold purpose may be achieved.

As a preliminary to the discussion of the various phases of heat treatment associated with hollow mining drill steel, a few remarks concerning the constitution or metallographic structure of drill steel, although elementary, will not be out of place at this stage, to enable a full appreciation and understanding of the reasons why indifferent performance can be expected if certain very definite but not unduly restrictive limitations in respect of forging and heat treatment practice are not observed

Plain carbon steels consist of two constituents known as ferrite and pearlite. The former, light etching grains predominate in low carbon steels and lessen in amount as the carbon content increases, until at approximately 0·90% carbon, or what is known as the eutectoid composition, it is entirely replaced by the darker etching constituent, pearlite. Ferrite, which is soft and ductile, is a pure carbonless iron. Cementite, on the other hand, is hard and brittle and contains approximately 6·7% of carbon. Pearlite is a mixture of both which exist as alternate lamellae.

These steels when heated undergo no change of structure until a temperature of approximately 700°–730° C. is reached, when the pearlite transforms to a non-magnetic austenite, i.e., the pure iron changes its form from the alpha to the gamma phase, in which state it takes into solution the iron carbide and forms the constituent known as austenite. The temperature at which this transformation takes place is known as the thermal critical point. The chemico-physical change occurring at this temperature results in an entirely new structure being formed, at which point maximum refinement of the grain takes place. With increase of temperature above this point the grains grow by a process of coalescence, the ultimate size depending upon the temperature to which the steel is heated.

Mechanical work or forging above the thermal critical range is known as hot work, during which process the grains of austenite are being continually deformed. The deformation is, however, only temporary, as the grain fragments will at once recrystallise and grow rapidly to a definite size corresponding to the temperature above the critical point at which forging was suspended.

If mechanical work is carried out below the critical range, which in normal practice is known as cold working, the grains, which will now be pearlite, are deformed, but no recrystallisation takes place and the structure as a consequence will remain in a deformed and strained condition, the degree depending upon the severity of the work and the temperature at which it ceased.

Forging Shanks and Bits

From the foregoing it is very apparent that care and attention to detail in the forging operation contribute in no small measure to the ultimate performance of the steel in service. The behaviour of drill steel, which has been closely controlled through all stages of its production, can be impaired by faulty forging technique.

It is well known that the higher the temperature to which the steel is heated for forging the more easy that operation becomes on account of the increased plasticity of steel at high temperatures. It is not, however, so well known or appreciated in mining circles that the detrimental effects of initial temperatures higher than

* We are indebted to the Australian Institute of Mining and Metallurgy for permission to present this paper, which was read at the Annual Conference at Newcastle, N.S.W., in May, 1947, but has not hitherto been published.

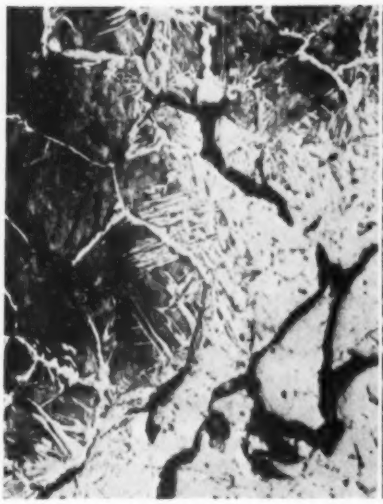


Fig. 14.—Typical "burnt" structure. × 100

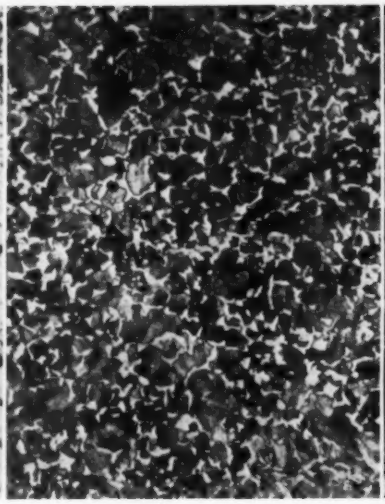


Fig. 15.—"As rolled" structure. × 100

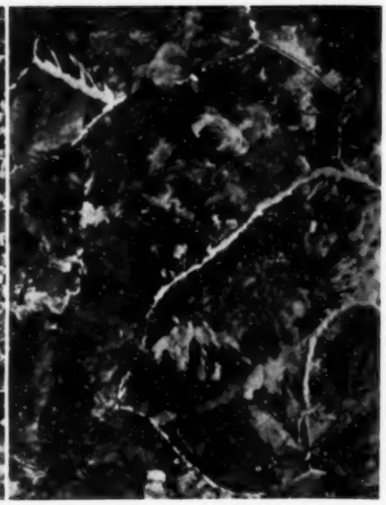


Fig. 16.—Structure on heating to 1,150° C. × 100

prescribed, with a resultant high finish forging temperature, are difficult and sometimes impossible to eradicate entirely by any subsequent thermal treatment.

Quite apart from this, it is important to note that these comments do not include overheating to the point of burning, which occurs on steels such as high carbon drill steel at temperatures in excess of 1,100° C. The furnace atmosphere has also an important bearing in achieving this undesirable condition, since a turbulent oxidising atmosphere will cause the steel to burn at a lower temperature than when the atmosphere is of a quiescent reducing type. When such conditions exist, the grain boundaries may partially fuse and the steel is rendered useless for all practical purposes.

On the other hand, the detrimental effects of forging or performing any mechanical work on the steel after it has fallen below a temperature of approximately 780° C. cannot be emphasised too strongly, since forging work carried out below this temperature progressively distorts the structure and induces a considerable degree of stress in the bit or shank which, if severe enough, is liable to produce cracks of varying intensity.

The most desirable temperature to which drill steel should be heated for forging is one which will not only be high enough to enable the necessary forming to be done, but permit finishing of this operation before the temperature has fallen to 800° C. This, from experience has been found to be approximately 1,000°–1,050° C. The precise temperature depends to a large extent upon the speed and skill of the operator, but at all times it should be borne in mind that the lower the maximum forging temperature consistent with finishing the operation at or just above the critical range (which for practical purposes can be considered to be 800° C. for this steel) the better will be the end results.

Two further aspects worthy of note in the forging process as affecting the serviceability of bits and shanks are :—(1) The amount of the bar to be heated should be kept to the minimum requirements. Should this be excessive, portions of the bar will suffer from being heated to the forging heat with no subsequent mechanical work to refine the grain. (2) The furnace atmosphere should be kept slightly reducing in order to prevent decarburisation. If the latter condition is induced, the hardened bit will go into service with a soft skin having inferior cutting ability, will prematurely flatten out, and be returned for rehardening as a soft bit. Consideration of these facts indicate the detrimental results which can accrue from inattention to the points outlined.

Particular care should be taken to shape the bit to the correct form and size. A bit which has uneven length of wings, sharp fillets and indentations, folds or overlaps, is naturally susceptible to breakage.

The reaming edge requires attention to ensure that the bit will drill to gauge. Forging tools also require frequent attention, as, apart from sharp corners on shanking dies, which are potential sources of weakness in connection with causes of fatigue failures, etc., worn dies and dollies mean poor bits and shanks which militate against ensuring satisfactory drilling performance.

When the forging operation is completed, the bit or shank should be allowed to cool in the atmosphere until all colour has disappeared before any further treatment is proceeded with.

Heat Treatment of Bits

Reverting to the discussion on the constitution of drill steel, it will be recalled that on heating through the thermal critical range the pure iron changes its form from the alpha to the gamma phase, in which condition the solubility of iron carbide increases considerably. It is on this fact, i.e., the change in solubility of iron carbide in the iron matrix, that the heat treatment of steel is based. When steel is rapidly quenched to atmospheric temperature after the iron carbide has been taken into solution by heating above the critical point, the gamma to alpha transformation is abnormal and the iron carbide then exists as a supersaturated solid solution metallurgically known as martensite. This is the constituent necessary to ensure the required hardness on the cutting edges of the bit.

After cooling from the forging heat, the bit ends are reheated to 790°–800° C. or just above the thermal critical range, and held at this temperature only long enough to ensure even distribution of the temperature

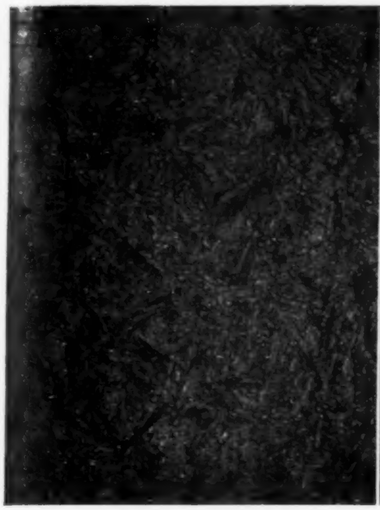


Fig. 17.—Structure on heating to 1,150 °C. followed by oil quenching. from 800° C. × 100

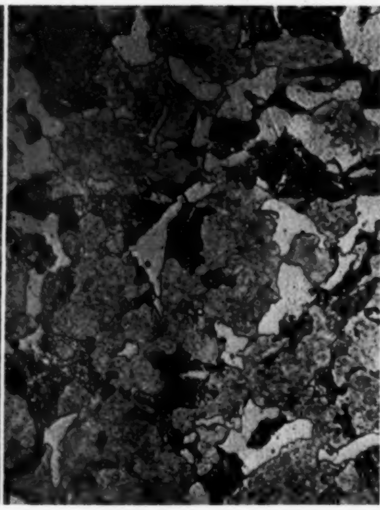


Fig. 18.—Improperly hardened structure. × 500

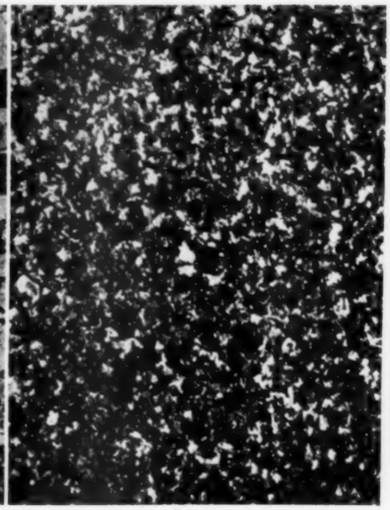


Fig. 19.—Properly hardened structure. × 500

throughout. Unnecessarily high temperatures adversely affect the steel by inducing grain growth and, as each austenite grain on hardening becomes a grain of martensite on quenching, the desirability of having the finest possible austenite grain becomes evident, since toughness is a function of grain size, the influence of which increases in importance as the hardenability of the steel rises. On the other hand a temperature lower than that recommended results in uneven or only partial hardening, either of which conditions adversely affects drilling performance.

When the bit is thoroughly heated, it is tip-quenched in water or brine. The type of quenching tank in most common use consists of a shallow tank with a perforated sheet steel grate submerged beneath the quenchant to a depth of from $\frac{1}{2}$–$\frac{3}{4}$ in. When the bits are placed on this grate the points only are hardened to approximately the depth immersed in the coolant with the hardness tapering off into the body. By this means a tough backing is ensured with the hardness gradually increasing to the tip where it reaches an almost glass hard condition.

For uniformity it is important to keep the quenching medium circulating to obtain an even temperature throughout the bath, which itself should preferably be maintained at approximately 20°–30° C.

Treatment of Shank

The same general principles apply for the shank treatment as described for the bit, with the exception that oil should be used as the quenchant. The procedure is similar to that followed in hardening the bit, in that the heating should be long enough to ensure uniformity, and should overlap the forging heat to get rid of residual forging stresses, as well as produce the necessary grain refinement. As distinct from the bit, however, the entire shank is immersed in oil and vigorously agitated until cooled to hand temperature.

With this treatment a hardness varying from 350–450 Brinell will be obtained which has been found very satisfactory for normal usage. Anything softer than the minimum limit stated predisposes the shank to upsetting in the machine, particularly if the ground being drilled is unduly hard, or if the air pressures at the rock face are on the high side. Conversely, shanks above the upper hardness limit stated are liable to cause piston damage with consequent increased maintenance costs.

When the throughput of hardening is high, a frequent cause of soft shanks is hot oil, resulting from either absence of circulation for cooling purposes or insufficient oil in the system to accommodate the number being dealt with. It will at once be evident that, if anything like uniformity is to be maintained in shank treatment, a sufficient quantity of oil or an efficient cooling system is required to keep the oil temperature within the limits of, say 30°–60° C.

From the foregoing notes on bit and shank hardening and in preparation therefor, it can be realised how important it is to pay attention to the minutest detail if the best results from the steel and the lowest drilling costs are to be attained.

The photo-micrographs exhibited in Figs. 14–19 convey an idea of the structures obtainable under the several conditions named.

Failure of Hollow Drill Steel

Fatigue Failures

Since practically all drill failures arise from fatigue, a discussion of what is meant by this term and the factors affecting it would not perhaps be inappropriate.

When steel is subjected to alternating stress of sufficient magnitude, at the end of a period of time governed by the degree of loading and frequency of the alternation, there forms a minute crack at or near the point of maximum stress. This crack gradually extends in depth until finally the area of metal unaffected is not sufficiently strong to support the load, and complete fracture takes place. Such an occurrence is known as failure by fatigue. The plane of fracture has a characteristic appearance and its progress can be followed by the presence of a series of semi-circular lines with the original crack as the datum point. Immediately behind the largest of these more or less concentric lines, i.e., the last one to form, the appearance of the surface changes from the flinty to the crystalline type characteristic of that

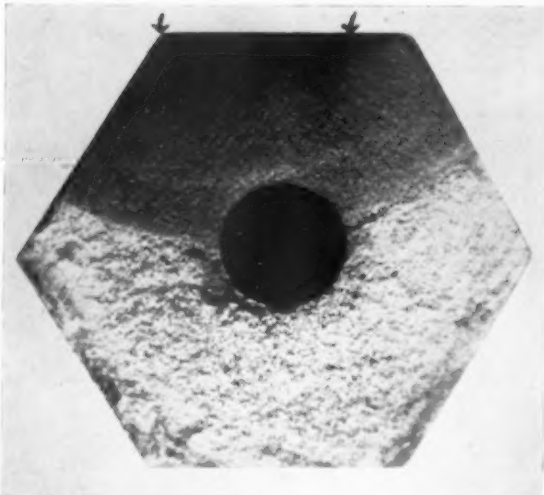


Fig. 20.—Minute surface flaws forming focal points in originating progressive fatigue fractures.

produced when a bar of steel is suddenly fractured by a single heavy blow. This crystalline area represents that part of the section where fracture was instantaneous, when the part was so weakened by the gradual enlargement of the original fatigue crack that it could no longer sustain the load.

It is often stated that the fatigue failures are caused by the " crystallisation " of the steel, and that " resting " will assist in overcoming the trouble. The former conception is definitely erroneous and in the case of hollow drill steel " resting " is not only no cure, but may be dangerous, as will be shown.

Almost without exception, fatigue failures originate on a surface, and this is most significant since slight surface defects become points of stress concentration and their presence hastens the onset of the trouble. In the case of hollow drill steel there are two surfaces to be considered, namely the outer surface and that of the central hole, and users of drill steel should take care to ensure that the original surface as furnished by the rolling mills is damaged as little as possible, both above and below ground.

Fatigue failures may occur at any point in a hollow drill, but it is often observed that one mine is more prone to encounter fractures at a particular area than another, despite the fact that operating conditions appear to be identical.

Failures in the region of the shank and collar are a fairly common occurrence, and can be attributed to several factors. Apart from the question of heat treatment, the principal causes of trouble are :—

1. Improper forging of the shanks.
2. Bad alignment of drill and machine.
3. Worn machine bushings.

If shanks are not correctly formed during the shaping operation, forging laps and sharp nicks are often produced in the region of the collar, not only on the outer surface but on that of the central hole also. Defects such as these act as stress raisers and have a very potent influence on the initiation of fatigue cracks. Operators, therefore, should make sure that forging machine dies are designed in such a manner as to prevent the formation of these faults.

After starting the hole, the machine operator should check the alignment of the drill and the machine. Otherwise severe bending stresses are imposed on the drill rod, quite apart from the unnecessary selective loading on the machine. Since the steel is already subject to heavy alternating stresses in its normal operation the additional stress resulting from misalignment is often the straw which breaks the camel's back.

When the machine bushing becomes worn it is found to bear heavily on the collar and transmit an appreciable proportion of the hammer's impact to that point. This results in mechanical deformation of the collar with consequent work hardening of the steel. Such work hardened and deformed zones are fertile ground for the development of fatigue cracks, and the occurrence of drill failures from this cause alone is sufficient reason to warrant paying careful attention to drill bushes.

On the main body of the drill the cracks are almost invariably associated with surface imperfections such as nicks and bruises, produced by careless handling in transit by rail or sea or at the mine itself, rust pits, and the like. Fatigue cracks can also commence on the surface of the central hole, particularly as already stated when corrosive waters are used, since such conditions hasten the onset of the trouble.

To lessen the incidence of failure from corrosion fatigue, particularly in the bore, it must be emphasised that hollow drill steel should not be rested, but kept continually in service to prevent the development of rust pits. For this reason there should be a greater appreciation of the fact that mining steels are more liable to fracture when used intermittently than when in continuous service.

At the bit ends of the drills fatigue failures seem, in our experience, to be less common, and generally speaking are initiated by forging defects and insufficient backing up of the bit, which is of course, a question of design.

Careful attention to all the foregoing factors will reduce the likelihood of premature failure of drill steel by fatigue, but consideration must also be given to the severity of operating conditions. Excessively hard ground or high air pressures at the machine will impose additional stress on the drill, and such conditions may demand an increase in the size of the rod or substitution of the more fatigue-resisting alloy drill steels.

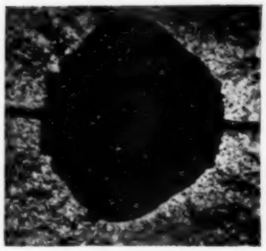
Failures Resulting From Faulty Thermal Treatment

Although modern good quality hollow drill steel can withstand a certain amount of misuse in heat treatment, completely satisfactory results cannot be assured if the heat treatment is not correctly carried out. This fact is becoming more widely appreciated and progressive mine managements are taking increasing interest in treatment methods and directing their energies towards improving the efficiency of their heat treatment practice.

Particular care must be taken when heating blunts for reforging. Blunt steels should be heated slowly, since sudden heating can produce cracks in the already hardened zone. These do not weld in the steel but are forged in and form laps serving as starting points or nuclei for the propagation of cracks in the subsequent quench hardening operation.

Fig. 21 (left).—Two halves of a 1¼-in. dia. drill rod revealing corrosion pits from which fatigue cracks can form.

Fig. 22 (right).—Longitudinal section of a 1¼-in. dia. drill rod showing the type of crack which results from corrosion when the steel is stressed.



MACHINE OPERATION AND DRILL FAILURE

The condition of the machine and the care with which it is handled underground can also have a bearing on the life obtained from the steel. Worn bushings may damage the collar and also permit too free movement of the shank, thereby distributing the force of the hammer blow unevenly. Anvil blocks and pistons must be kept in good condition and should be square and parallel to the end of the shank if distortion is to be avoided. By the same token, shank ends should be ground square and the holes slightly countersunk. Failure to do this may damage the piston.

Excessive air pressure on drill rod which is too light will produce fatigue failures. This factor should be adjusted to suit both the size of the section and the type of ground being drilled. For instance the penetration per blow in soft ground is often so great as to clog the bit and impose heavy stresses on the steel. This condition may be adjusted by employing a softer blow or modifying the bit so as to ensure shallower penetration. It is well, therefore, to give careful consideration to bit design as it has been found on numerous occasions that relatively slight modifications to bits have resulted not only in increased steel life but in better drilling performance.

The illustrations in Figs. 20, 21 and 22, reveal typical sources of fatigue failure from external surface faults and corrosion in the bore.

Suggested Establishment of a Central Testing or Proving Station

For the purpose of dealing with problems associated with metalliferous mining in the Commonwealth and to enable Australian mining engineers and metallurgists to have the opportunity of finding their own means of solving them, the writer suggests for consideration the setting up of a central testing or proving station.

Hitherto we have largely drawn upon world experience and practice, and the time now seems ripe to seek improvements by developing methods to suit our own particular conditions in all phases pertaining to the mechanical aspects of mining. Among the problems that might be assigned to such an experimental centre is the determination of the best drill rod composition to employ for the use on the hardest, medium and softest types of rock or stone, because it is conceivable that what proves most economical for material on the highest scale of hardness would not be equally economical on the lowest. Moreover, the design of the bit may require to be altered to suit the variations in ground from mine to mine, if optimum drilling results are to be ensured.

Another aspect of importance to mining engineers that could profitably be investigated is the matter of detachable bits. From the fact that there are so many types on the market it appears there is yet much to be done in evolving a design that will suit all conditions. The question of design and performance under the many variables encountered in Australian mining could be more satisfactorily solved, in the first instance, at a central station than at the mine itself. It is conceivable that carefully controlled tests under proper supervision may prove that even the best design of detachable bit it is possible to evolve may have only a very limited overall application.

It would be necessary, however, if the maximum results are to be obtained, for suitably sized samples, truly representative of the various metallic rocks or materials being mined, to be forwarded to the testing or proving house, so that the conditions at the mine could be simulated as far as practicable.

In order to assist still further in reducing mining costs, an experimental ball mill could be set up and research undertaken not only to improve the life of the grinding balls but that of the mill liners themselves. Another phase of the milling problems that could be explored is the speed of rotation of the mill and the optimum weight of grinding media to ensure effective grinding at the lowest cost on all the varied types of ore, etc., encountered.

When experimental work showed improved results and economies were indicated, the testing station personnel would then be expected to proceed to a selected mine and put into practice, under actual operating conditions, what they had determined by experiment.

These are only some of the problems that could be profitably dealt with by such a central station. Doubtless there are others.

With regard to the cost of establishing a proving house to deal with problems peculiar to mining, it is suggested that each mine should make a contribution in accordance with its importance. It is also suggested that the officials allocated to man the station should be experienced men familiar with the work, who know what they are seeking and who can go into the mine and put into practice what they have learned experimentally. It is possible it might be found that after a few years' work all the major problems had been, for the time being, solved, in which case it might be found difficult to continue to operate the station. If and when such a position developed, the personnel could be returned to their jobs on the mine, the station closed, and reopened only when new problems presented themselves as they are certain to do from time to time.

Concerning the metallurgical investigations that would inevitably be involved in the event of a central proving house being established, Australian steel producers on their part would be most willing to extend the fullest measure of assistance.

If the implementation of such a scheme were considered too ambitious, then, as an alternative, a particular mine could be selected to carry out any

experimental work required, the cost of which would be borne by the mines participating.

Concluding, the author takes this opportunity of thanking the Commonwealth Steel Company Limited for their permission to use the illustrations presented in this paper; and to his colleagues, Messrs. A. M. Bennett, H. R. Dalziel and W. Sutherland, for their valued assistance in its preparation.

High-Temperature Steels and Alloys for Gas Turbines

Iron and Steel Institute Symposium—II

A symposium on high temperature steels and alloys for gas turbines, arranged by the Iron and Steel Institute, was held in London in February. An account of the first day's proceedings was presented in the March issue and in the following pages we present the remainder of the proceedings dealing with special blading materials, scaling and elevated temperature fatigue, user aspects, and research and future needs.

THE Symposium on High Temperature Steels and Alloys for Gas Turbines, arranged by the Iron and Steel Institute, took place on Wednesday and Thursday, February 21st and 22nd, 1951, in the Great Hall of the Institution of Civil Engineers. The papers presented and the discussion which took place at the meeting will be issued as a single bound volume (No. 43 of the Special Report Series of the Iron and Steel Institute), the published price of which will be three guineas. In the following pages a brief account of the second day's proceedings at the Symposium is given. No attempt is made to digest the papers presented, as they contain such a wealth of detail that it would be impossible to do justice to them in the available space. An idea of the scope of the various papers will, however, be gained from the remarks of the rapporteurs dealing with the several groups.

Special Blade Materials

The papers presented in this section included the following:—

Chromium-Base Alloys for Gas Turbine Applications. By E. A. G. Liddiard and A. H. Sully.
Some Cobalt-Rich Alloys for High Temperature Service. By J. C. Chaston and F. C. Child.
Phase Diagrams of the Ternary Systems Fe-Cr-W and Fe-Cr-Mo at Low Temperatures. By H. J. Goldschmidt.
Sintered Alloys for High-Temperature service in Gas Turbines. By R. W. A. Buswell, W. R. Pitkin and I. Jenkins.
Ceramics as Gas-Turbine Blade Materials: A Survey of the Possibilities. By T. G. Carruthers and A. L. Roberts.
Ceramics for Gas Turbines. By L. Rotherham, W. Watt, J. P. Roberts, and F. J. Bradshaw.
Sweat-Cooling: Review of Present Knowledge and its Application to the Gas Turbine. By P. Grootenhuis and N. P. W. Moore.

In the course of his introduction to the papers, the rapporteur, PROFESSOR G. WESLEY AUSTIN (Cambridge University) said that a careful study of the seven papers showed that, after thinking over their subject matter and results, the various authors had doubts on certain points. He proposed, therefore, to indicate those points so that attention could be directed towards them in the ensuing discussion, with a view to minimising the uncertainty which existed.

Turning to the last paper first, Professor Wesley Austin said the paper on sweat-cooling was extremely important in view of the material shortage prevailing. The object was to cool the surface of the blade by making it of porous material and passing a fluid through the fine pores on to the surface. In that way heat was extracted from the porous material, and an insulating layer was formed on the surface to reduce the pick-up of heat from the hot gases. The problems associated with the method were the development of a consistently reliable material, with controlled continuous porosity, and the design of blades suitable for sweat-cooling. The authors also drew attention to the lack of knowledge of the fatigue strength of powdered compacts, a matter of considerable importance to the designer using them as blades.

LIDDIARD and SULLY and GOLDSCHMIDT had taken an extremely logical step. They had argued that if designers wanted them to produce alloys capable of withstanding higher temperatures, they must raise the melting point of the base metals. LIDDIARD and SULLY had investigated the chromium-base alloys and presented a most interesting paper in which he detected two ominous notes. The first concerned the difficulty of casting chromium alloys, for which the authors recommended the use of argon. That should not be taken as too serious a drawback as there was a likelihood of using oxygen and oxygen-enriched air to an increasing extent in extraction metallurgy, and argon could probably be recovered, without too much difficulty, from the tonnage oxygen plants, with a consequent reduction in price. The other drawback referred to was the brittleness of chromium and its alloys at room temperature, although the authors had stated that, as far as they could see, the chromium alloys were quite reliable at the temperatures for which they were proposed.

GOLDSCHMIDT had made a different approach: he had considered the binary and ternary systems, including not only chromium but iron, molybdenum and tungsten. His paper was very fundamental and such was the state of the science that he was able to give guidance as to which were the promising areas of the diagrams.

The papers by CHASTON and CHILD, and BUSWELL, PITKIN and JENKINS dealt with alloys based on cobalt, the former using alloys made by conventional methods and the latter by powder metallurgical techniques. The alloys investigated by CHASTON and CHILD were of the

cobalt-chromium-tantalum type, that containing 10% each of tantalum and chromium and 0·3% carbon having been given special attention.

Buswell, Pitkin and Jenkins had prepared, by powder metallurgical methods, a cobalt-base alloy of the Vitallium type and compared its properties with those of the cast alloy. The room temperature properties compared favourably with those of the cast material, but whilst the high temperature fatigue properties were encouraging, the creep properties, at least above 600° C., were comparatively low. The authors suggested that the lower carbon content might be the important factor.

Carruthers and Roberts had given an excellent survey of the whole field of ceramics and had come to the conclusion that sintered oxides gave the most immediate promise. Although they might not as yet be applicable to gas turbines, they might play a part, indirectly, in the melting of the higher melting point alloys. Rotherham, Watt, Roberts and Bradshaw dealt in detail with sintered alumina, and amongst the useful information given was the statement that, at 1,000° C., the properties of alumina in bending exceed those of any known used metallic material.

Discussion

Dr. H. Sutton (Ministry of Supply), in opening the discussion, referred first to the chromium-base alloys on which valuable work had been carried out by Liddiard and Sully at Fulmer, and by Cross, Parke and their colleagues at Battelle. A point of particular interest was the way in which a transition from tough to brittle condition seemed to occur in pure chromium, but he thought that Havekotte and Greenidge found no sharp transition in the impact properties of their alloys between 80° and 1,800° F.—a very interesting observation. Kroll in his April, 1950, paper to the Electrochemical Society had mentioned his experience of a very pure chromium powder which could be compacted, sintered and rolled: at 650° C. it was malleable and could be bent. Kroll stated that the powder probably contained 0·1% oxygen and it seemed clear that if the brittleness at low temperatures were due to impurities, it must be caused by very small amounts. Whilst it was true that the cobalt-base alloys were in a special category due to supply difficulties, there were indications that the supply position could be improved, and there were one or two applications in which an alloy, strong at temperatures which were high even for turbine parts, could be used in small amounts with great advantage. Particularly interesting was the effect of carbon content on stress-to-rupture performance. The results obtained by Buswell, Pitkin and Jenkins were encouraging, suggesting that engineering properties could be obtained in an unworked sintered product. The further work projected, on alloys containing carbon, seemed likely to prove interesting. The study of ceramic bodies was of special interest and a material developed by the Bureau of Standards—beryllia-zirconia-alumina—had shown considerable promise. The contribution by Grootenhuis and Moore was a timely one in which one had to balance the loss of mechanical properties due to porosity against the benefit resulting from the lower temperature due to cooling.

Dr. Howard Cross (Battelle Memorial Institute, U.S.A.) referred to work on chromium-base alloys carried out at Battelle in recent years. Most of the effort had been concentrated on chromium-iron-molybdenum alloys in the range 60 : 15 : 25 to 60 : 25 : 15. Most of the alloys were vacuum melted and vacuum cast, although a few had been melted in air with a slag covering. Although such alloys had very attractive high-temperature properties, the room temperature ductility was very low, and many experiments had been made to improve it. As the grain size decreased, shock resistance increased, and for a given grain size, alloys with more than 0·06% oxygen showed higher degrees of shock resistance than those with lower oxygen contents. The high oxygen contents were probably associated with lower carbon contents and carbon might be the significant variable. The alloys had some ductility, however, and experiments on crystals of chromium metal prepared by the iodide method showed appreciable ductility under slow deformation. As that was the purest metal they had yet produced, Dr. Cross suggested that future work should be directed towards a study of the pure metal rather than the alloys, with a view to determining the factors affecting ductility.

Mr. W. Woodward (United States National Advisory Committee for Aeronautics) said that although they had done considerable work on ceramics in America, they had yet to produce a material which could be used as a blade, the main drawback being the poor thermal and mechanical shock resistance. The trend seemed to be toward the addition of metals, producing "ceramels" which showed some promise. The American methods of manufacture were somewhat different, using high temperature pressing in graphite dies, or rubber sleeve moulding in which a rubber mould was filled with powder and subjected to hydraulic pressure in an oil-filled chamber. Materials prepared by those methods showed different properties from those prepared by cold pressing or slip casting. The materials of the ceramel type which they had investigated were titanium-carbide based with molybdenum, nickel and iron as binders. With nickel the properties of the cobalt-bound alloy were approached—a significant result in view of cobalt scarcity.

Mr. S. T. Harrison (Armstrong-Siddeley Motors, Ltd.) gave an account of his experiences in running titanium carbide blades. Based on titanium carbide, with nickel or cobalt matrix, chromium was added as a carbide and the method of manufacture was similar to that used for tungsten carbide. Increasing the carbide content increased the creep strength but made the material more brittle. Alloys bonded with cobalt had better creep properties than those bonded with nickel but gave difficulties in grinding. Chromium improved the resistance to scaling. It was decided to use materials which had reasonable strength and, although brittle, were not sufficiently so to be incapable of being handled and run. Excellent running results were obtained but trouble was experienced due to failure at the root fixing as a result of stress concentrations and the lack of ductility. Photo-elastic investigations pointed the way to overcome the difficulty and spinning tests were being carried out with modified root serrations, and he had little doubt that a satisfactory solution would be found. There were indications that blades could be sintered very close to form, which would make them an attractive economic proposition. There was, obviously, a limit to the extent to which brittleness could be tolerated, but it should be determined by the amount of impact the blade had to stand from flying particles, rather than by methods of fixing.

Dr. J. D. Nisbet (General Electric Co., U.S.A.) said his remarks would not be a discussion of the papers, but rather a brief description of the work they had been carrying out during the last four years. They had studied the cobalt-nickel-iron-chromium quaternary system, varying each element in turn, and had then introduced what he called incongruous elements, such as tungsten, molybdenum, tantalum, titanium, zirconium, aluminium, carbon, beryllium, etc. If cobalt were increased, the ratio of the other three remaining fixed, the high temperature properties were increased somewhat; increased chromium increased the properties markedly; increased iron decreased the properties, and so, to a slight extent, did increased nickel. It could be concluded therefore, that whilst cobalt could not be substituted directly by nickel or iron, it could be substituted by those metals if chromium were increased or some incongruous element added. They believed that the same properties could be obtained by wandering back to the more iron-rich and nickel-rich materials, and taking advantage of the available elements such as titanium, in preference to those which, like tantalum, were scarce. Taking all the results together, it seemed that they were on the threshold of alloy design, and that it would be less necessary in the future to add a little of this and a little of that

Mr. P. Grootenhuis (City and Guilds College, London) pointed out that sweat cooling differed from other forms of cooling in that, although the temperature of the gas stream was reduced, the heat content remained the same. Although the paper had dealt with its application to turbine blades, the principle could be applied to the cooling of ducts, etc., in land turbines. That would involve the production of sheets, and recent German work had shown that "green" sheets could be produced by rolling direct from powder and could then be sintered and re-rolled to increase the density. Much development still remained to be done on the mechanical properties, but since the paper had been given a number of workers had published the results of fatigue tests on porous metals.

Mr. F. J. Bayley (National Gas Turbine Establishment) referred to practical experiences of sweat cooling, using porous bronze sheet in a duct, in which extremely efficient cooling was effected. The heat transfer conditions prevailing in different parts of the duct governed the volume of cooling air needed, but, even under the most arduous conditions, sweat cooling was the most efficient and effective technique tried. The main problem in fabricating ducts was in making the necessary joints, but recently developed welding processes had shown a large degree of success in overcoming the trouble. The construction of sweat-cooled blades was, however, not so easy, particularly when one considered the extremely thin trailing edge necessary for high efficiency. Finally, there was the difficulty of blockage. This probably presented the least difficulty as the deposits of solid matter in the pores could usually be removed by an air blast from the reverse side, or, better still, a comparatively crude filter could be used to remove dust particles before the air reached the pores.

That experiments had shown that it was possible to produce porous materials by simultaneously pressing and heating layers of woven wire gauze was disclosed by Mr. S. Peerless (City and Guilds College). The advantage of the product included more uniform porosity, greater strength, an easier and cheaper method of construction for simple shapes, a co-efficient of expansion nearer to that of solid metal, and an easier method of achieving high porosity. The method was complementary to the powder method and it might be possible to combine the two.

Mr. N. P. W. Moore (City and Guilds College) referred to a further aspect of sweat cooling which had arisen since the paper was prepared, namely the use of fuel for sweat cooling, a development which had interesting possibilities.

Performance Aspects: Scaling and Fatigue at Elevated Temperatures

The following papers were presented and discussed:

The Scaling of Gas Turbine Alloys. By A. Preece.
Scaling of Heat-Resisting Steels: Influence of Combustible Sulphur and Oil-Fuel Ash Constituents. By C. Sykes and H. T. Shirley.
Fatigue at High Temperatures. By H. J. Tapsell.
Fatigue Tests at Elevated Temperatures. By P. H. Frith.
Hot Fatigue Testing. By H. E. Gresham and B. Hall.
Variation of Elastic Moduli with Temperature for Various Steels and Pure Metals. By G. T. Harris and M. T. Watkins.

The rapporteur, Mr. D. G. Sopwith (National Physical Laboratory) referred first to the paper by Harris and Watkins which presented the results of determinations of the elastic modulus for 12 turbine steels, nickel and Armco iron at temperatures up to 800° C., and for aluminium up to 400° C. The normal decrease in the modulus was at a somewhat increasing rate, with rise in temperature, falling to 60–70% of the room temperature value at 700° C.

Turning to the papers on scaling, that by Preece presented a general review of the subject. It was not yet possible to forecast the effect of particular operating conditions on particular alloys, as instanced by the catastrophic oxidation of alloys containing more than 4% molybdenum at temperatures above 800° C., and the considerable effect of small amounts of cerium and thorium in the nickel-chromium alloys. Two factors which appeared to be important were sulphur and vanadium pentoxide. The former was absorbed in the scale, and at higher temperatures could form an oxy-sulphide complex at the metal/scale interface, which resulted in intercrystalline attack. Vanadium pentoxide had a comparatively low melting point and in the molten condition exercised a strong fluxing action on the oxide film.

In the careful work reported in their paper, Sykes and Shirley had investigated, apart from the factors mentioned by Preece, the effect of incomplete combustion, leading to alkali formation, and the effect of air/fuel ratio, which did not seem important in the absence of undue amounts of sulphur or vanadium pentoxide. Provided sufficient air was used for complete combustion, the 0·5% sulphur dioxide present in town's gas did not appear to have much effect. The effect of hydrogen sulphide was marked on some of the steels when sodium was present in the ash, leading to sodium-sulphate formation. Vanadium pentoxide at 750° C. caused severe attack on all the steels, even when only 1% was present. The most hopeful suggestion for minimising the effect of vanadium pentoxide appeared to be the addition to the fuel of components which would form vanadates of higher melting point.

The remaining three papers dealt with fatigue at high temperatures. Frith described modifications to N.P.L.

Continued on page 185

The British Industries Fair

Engineering Exhibits at Castle Bromwich

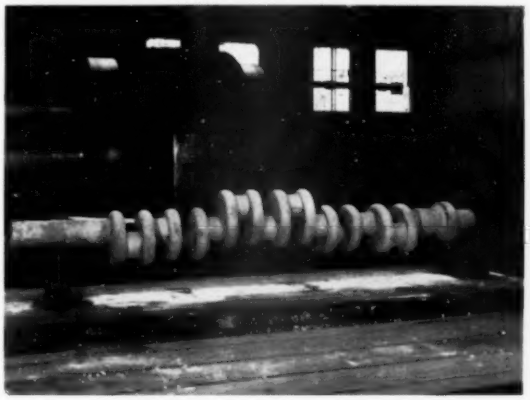
In spite of the need for rearmament, with its demands on man-power and production machinery, Britain cannot afford to relax her drive to increase exports to the world's markets. The displays of British products at Castle Bromwich, Birmingham, and at Olympia and Earls Court in London, will provide an indication of the efforts which are being made to this end. Apart from acting as a national shop window, the British Industries' Fair provides opportunities for personal contacts to be established with home and overseas buyers. In this survey of exhibits attention is mainly directed to metallurgical aspects of the Engineering Section at Castle Bromwich.

THE British Industries Fair, which opens on Monday, April 30th, at Castle Bromwich, Birmingham, and at Olympia and Earls Court in London, will be the thirtieth to be held since its inception in 1915. The three sections are organised by the Government of the United Kingdom, the Castle Bromwich section in close collaboration with the Birmingham Chamber of Commerce, and the London sections administered by the Commercial Relations and Export Department of the Board of Trade. The Fair has always been mainly concerned with the development of overseas trade, but the importance of this aspect has grown considerably in recent years, owing to the fact that the war consumed almost all Britain's overseas assets, from which she had formerly obtained food and raw materials. This has resulted in the necessity for a much greater proportion of her products to be sold overseas than was the case before the war. This year the shadow of material shortages is cast over industry but there are indications that, with due regard to the requirements of the rearmament programme, every effort will be made to meet the needs of the export market, although some curtailment of the use of scarce materials for home consumption must be regarded as inevitable.

In the space available, no more than a brief indication can be given of the exhibits in the Engineering section at Castle Bromwich which are likely to be of interest to those concerned with the production and use of metals in their various forms. In the following pages the exhibits are, in the main, classified according to their nature, the name of the exhibitor being given in the text, along with the stand number. Almost all the exhibits referred to will be found in Sections C and D in the Exhibition Hall, or on the Outdoor Stands. The numbers in parenthesis, following the exhibitor's name, refer to the location of the stand.

Wrought Steel

On Stand D541/438 will be shown, for the first time in this country, a 10 ft. six-throw diesel engine crank-shaft, press-forged by the R.R. Continuous Grain-Flow Process, sole British rights for which have been obtained by the exhibitors, ENGLISH STEEL CORPORATION, LTD. Although possessing all the advantages of a drop forging, it would be quite outside the scope of any British drop forge, and even bigger crankshafts are contemplated. Other products on view will include a section of a hollow-forged boiler drum, oil-well drilling equipment, a forged steel pipe mould, gas turbine discs, crankshafts for aero and commercial vehicle engines, springs and torsion bars.



Courtesy of English Steel Corporation, Ltd.

Crank-shaft forged by the R.R. Process.

A very wide range of steel products is covered by the various branches of THE UNITED STEEL COMPANIES, LTD. (D519), and although space precludes exhibition of them all, full information will be available, and the technical staff in attendance will be ready to discuss them with visitors. In the display, the accent will be almost entirely on 'Silver Fox' stainless steel, a range of materials differing completely in composition, treatment and properties, in a way which is not always realised by the user who is proposing to solve a corrosion problem by employing 'stainless steel.'

As long ago as 1850, James Mills was supplying the engineering industry with keys and other products. Since that time the firm has progressed until to-day EXORS. OF JAMES MILLS, LTD. (D503/400) are the largest makers of bright steel bars outside the U.S.A. The company has also specialised in the lead-bearing Ledloy steels which have been responsible for greatly increased speeds of machining. Exhibits concerning these two items will be shown, along with keys, cotter pins, taper pins, Mills patent grooved pins and studs, and a range of railway track fastenings.

The name of Firth has been popularly associated with stainless steel since the time of Harry Brearley's connection with the firm. More recently, in association

Courtesy of David Brown Foundries Co., Ltd.

Turbine casing for South African power station.

with English Steel Corporation, FIRTH-VICKERS STAINLESS STEELS, LTD., came into being and is now responsible for the "stainless" business of the two companies. Exhibits on Stand D419/318 will include stainless steels and heat- and creep-resisting steels in the form of sheet, strip, bars, forgings and castings.

Well-known in the field of rolled steel products, LEE OF SHEFFIELD, LTD. (D.528) will be showing a selection of bright steel bars, cold-rolled steel strip, high grade steel wire, stainless steel strip and wire—all principal manufactures of the company, along with a selection of articles made from stainless steel.

GUEST, KEEN AND NETTLEFOLDS (MIDLANDS, LTD.), will have two stands again this year. On B629/526 will be displayed a wide range of screws, nuts and bolts, hot- and cold-rolled strip and a variety of railway fastenings. Outdoor Stand 1325/1224 will feature exhibits of the G.K.N. group of companies including upset and drop forgings, and press forgings by JOHN GARRINGTON & SONS, LTD., and galvanised, corrugated and flat sheets by JOHN LYSAGHT'S BRISTOL WORKS, LTD.

Wrought ferrous materials are included in the products of the THOS. W. WARD, LTD. group of companies whose indoor stand, D719, will display photographs of those aspects of the group's operations which cannot be exemplified by actual machines or equipment, including the breaking up of famous fighting vessels to yield valuable scrap. The exhibits on the outdoor stand, 1360, will consist of examples of the range of machinery and industrial plant marketed by the parent company, together with unit displays showing the activities and products of the subsidiary companies.

Attention is also drawn to the stand of RICHARD THOMAS & BALDWIN, LTD. (D301/200), makers of a wide range of flat rolled steel products, steel sheet, tinplate, stainless steel, etc. Other products include electrical sheet steel, galvanised sheet, merchant mill products, etc.

On Stand D405/304, the BROCKHOUSE ORGANISATION (J. BROCKHOUSE & CO., LTD. and associated companies) will continue their policy of drawing attention to the whole of the vast range of products manufactured and marketed by the group. Space precludes a display of the whole range, which includes forgings and cold-rolled sections.

Stainless steel is a speciality of PADLEY & VENABLES LTD. (D525/422) and the exhibits will include sheet, strip, bars, tubes, sections, wire and castings, together with exhibits of manufactured articles produced from this material.

Ferrous Castings

Evidence of the versatility of THE DAVID BROWN FOUNDRIES COMPANY (D345) will be given by an impressive array of stainless steel castings, airframe and aircraft engine castings in heat-resisting and alloy steel, investment castings, and a variety of Taurus bronze castings produced by both sand and centrifugal processes. A particularly impressive exhibit will be a 3-ton top-half high-pressure steam-turbine casing for use in a South African power station. On the same stand DAVID BROWN-JACKSON, LTD., will display two outstanding examples of rolling-mill pinions.

On the EDGAR ALLEN Stand (D534), the steel foundry's largest and most interesting new exhibit will be a 3-ton body in cast steel for a bolt-forging machine. The steel industry's casting requirements are represented by a rolling-mill coupling box and a special chromium alloy steel hammer tool. The electrical industry is featured in a brake drum and pole wheel, while examples of castings for the Railway Executive include a pair of automatic coupler castings and a body casting for rolling stock slack adjuster equipment.

K. & L. STEELFOUNDERS AND ENGINEERS, LTD., will be exhibiting in the '600' Group Pavilion (Outdoor 1332). Among the exhibits will be a range of SCOA–P wheel centres, designed and patented by the Steel Company of Australia Pty., Ltd.

Reference has already been made, in the previous section, to the fact that stainless steel castings will be shown on the stands of FIRTH-VICKERS STAINLESS STEELS, LTD. (D419/318) and PADLEY & VENABLES, LTD. (D525/422), whilst three of the THOS. W. WARD subsidiaries, Outdoor 1360, are also manufacturers of castings in iron, mild steel and stainless steel.

New rotary-type melting furnaces equipped for mechanical charging have been installed to supplement the existing open-hearth furnaces at HALE & HALE (TIPTON) LTD. (D609/508) to meet the increasing demand for malleable iron castings. The display will include a wide range of castings produced for many industries including mining, electricity, road and rail transport, shipbuilding, agricultural implements and machinery, and the building and allied trades. A range of castings in Permalite will also be featured; this is a special high-duty alloy possessing superior mechanical properties to standard blackheart malleable iron, though it is not quite so ductile.

For more than a century, the STANTON IRONWORKS CO., LTD. (B626/717) steadily developed from a single 30-ft. high blast furnace to the vast organisation it is to-day, with 12 modern blast furnaces, four spun iron pipe plants, various mechanised foundries and continuous casting plants, as well as its huge concrete plants. The name of Stanton is closely associated with the centrifugal casting of iron pipes in water-cooled metal moulds and two of the largest size made, 27 in. bore by 18 ft. long, will be on view, along with special castings, concrete-lined spun iron pipes, flexible joints for gas and water mains, a range of pig iron, and coloured aerial photographs of the works.

JOHN HARPER & CO., LTD., of Willenhall, will show, on Stand A336, a representative selection of castings in

grey iron and Harper–Meehanite for all branches of the engineering industry. Attention will be drawn to the close adherence to dimensions, to the smooth skin of the castings and to the uniformity and density of structure. Also on view will be examples of Harper process work, featuring machined, enamelled and plated castings and pressed steel and sub-assembly work.

Further examples of malleable iron castings will be displayed on the stand of LEY'S MALLEABLE CASTINGS Co., LTD. (D513/410), indicating their use in the automobile, agricultural, electrical and general engineering trades. Castings may be supplied in two grades, the normal blackheart malleable iron with a U.T.S. of 24 tons/sq. in., and 'Lepaz' pearlitic malleable iron with a tensile range of 35–70 tons/sq. in.

On Stand D709, FOLLSAIN–WYCLIFFE FOUNDRIES, LTD., will again be showing examples of their composite nickel-chrome steel and heat-resisting cast iron dumper bars, together with a range of heat-resisting articles which will include carburising boxes in E.V. nickel-chrome heat-resisting steel, and in Penetral treated mild steel, firebars, pyrometer sheaths and furnace parts generally. Castings for ball mill lining, crusher lining, locomotive brake blocks and other abrasive duties will be shown in C.Y. erosion-resisting alloy, while the malleable iron castings will include the Wynip Girder Clip referred to in our columns recently.

The last decade has seen considerable progress in the technique of "lost wax" casting. On Stand A327/226, PRECISE CASTINGS will have on view a variety of such castings. These will include jet engine components in heat-resisting alloys, parts for textile machines in wear-resisting alloys, surgical castings such as bone plates in special corrosion resisting chromium–cobalt alloys, dentures cast in chromium cobalt alloy, and miscellaneous castings in nickel-chromium steels.

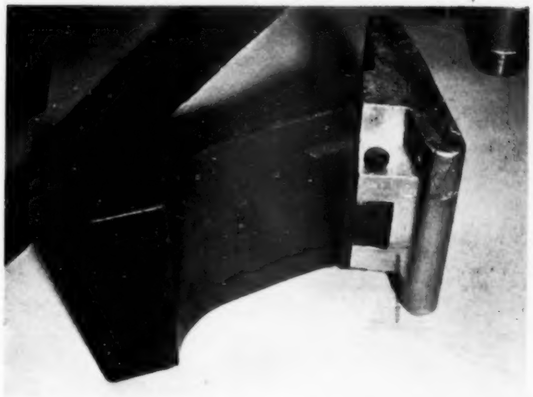
High quality castings from the FERRANTI foundry will be shown on Stand C615/514. Of particular interest will be a 3-ton, 7 ft. 6 in. diameter stator end ring made in Nomag, a non-magnetic cast iron pioneered by Ferranti.

Other manufacturers of ferrous castings who will be exhibiting include members of the BROCKHOUSE ORGANISATION whose Stand No. is D405/304.

Non-Ferrous Metals

The spirit of Festival year will be caught by the stand of the COPPER DEVELOPMENT ASSOCIATION (D232). The theme of the display will be "A Century of Progress in the Application of Copper and its Alloys," which will make possible a number of striking contrasts between equipment and techniques of 1851 and those of to-day.

For many years THOMAS BOLTON & SONS, LTD. (D642) have played a leading part in the development and manufacture of copper and its alloys for use in the electrical industry. Included in the exhibits will be "Combarloy," a special alloy for commutator segments, rail bonds for electric traction, 2- and 3-pole equaliser bars, rotor and stator end rings, H.C. bus-bars, wire and strip in copper, brass, and bronze, and trolley wire. Other exhibits will include tubes, extruded and drawn sections, machined parts, copper printing rollers for the textile trades, and locomotive firebox plates in de-oxidised arsenical copper. "Bush" brand chill-cast phosphor bronze solid and cored bars, and tungsten carbide drawing and extruding dies made from B.T.H. "Ardoloy" complete the display.



Courtesy of Follsain-Wycliffe Foundries, Ltd.

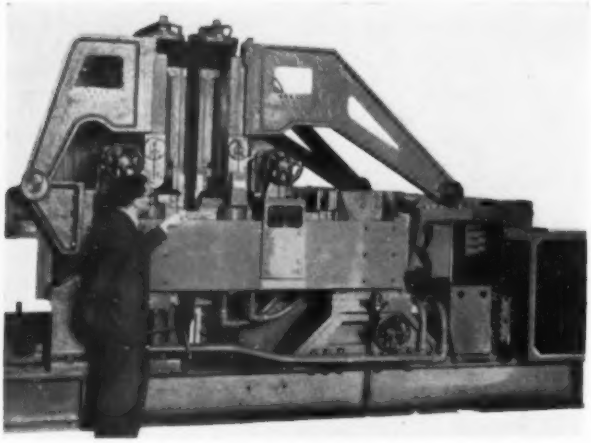
Composite nickel-chrome steel and heat-resisting cast iron dumper bar.

The principal wrought metal products of the METALS DIVISION of IMPERIAL CHEMICAL INDUSTRIES, LTD., will be shown on Stand D409/308. These will include strip, sheet, plate, tubes, rods, sections and wire in copper and its alloys and aluminium and its alloys. A number of features will receive special treatment: copper tubes for water, gas and sanitation services, including "Kuterlon" long length copper tubing for underground use and panel heating; copper printing rollers; "Kynal" aluminium alloy tread-plate (a new product); and extrusions in aluminium alloy for use in the main ribs of the Dome of Discovery, and for the construction of railway coaches.

A selection of the enormous range of extruded shapes and sections made by McKECHNIE BROTHERS, LTD., in various copper-base alloys will be seen on Stand D315. There will be samples of extruded rods in high-strength bronzes, including Narrmac, an alloy developed for jet engine components. Other examples of their products on view will be hot stampings in brass, bronze and white metal; bronze and nickel-silver welding rods; brass wire; ingots of phosphor bronze, gunmetal, yellow metal, nickel silver, antifriction metal and Terne metal; chill-cast phosphor bronze bars; granulated cupro-nickel; and solders.

An interesting display of copper alloy products will be found on Stand D514 (THE BIRMINGHAM BATTERY AND METAL CO., LTD.). Prominently featured will be condenser tubes in "Batalbra" aluminium brass, Admiralty brass, 70/30 brass, cupro-nickel and "Batnickon" a new copper-nickel-iron alloy which has proved highly resistant to sea-water corrosion. From the company's hot rolling mill will be shown a large naval brass condenser plate, 5 ft. in diameter and 6 in. thick, a phosphor bronze plate 12 ft. by 8 ft. by 1 in. thick, and a 1 in. thick aluminium bronze plate. Of special interest in the cold-rolled strip section will be a 3 cwt. coil of 24 in. wide copper strip as used for roofing.

The basic products of LANGLEY ALLOYS, LTD. (D404) are copper- and nickel-base alloys, and stainless steel castings. The most important of the copper alloys are the Hidurax aluminium bronzes and the Hidurel high conductivity alloys. Both these ranges are available as castings, forgings and bar; examples of the various forms will be on show, together with examples of applications. Other examples of copper alloys to be seen will include gun-metal castings, and castings and



Courtesy of British Federal Welder & Machine Co., Ltd., and The Steel Co. of Wales.

Flash welder for steel pickling line.

Courtesy of Rockweld, Ltd.

New type oxy-arc gun holder

stampings in Hidurit manganese bronze, alloys which are also available as forgings and rolled bar. In the field of nickel alloys, castings in Monel, nickel and Inconel will be shown in addition to the corrosion-resisting Langalloy 'R' series of alloys.

EMERY BROTHERS, LTD., is an old-established concern supplying the makers of Birmingham brass-ware. Its works have been modernised to meet demands of light production and electronic engineers in this motorised and refrigerated age. Brass, cartridge metal, gilding metal, copper and phosphor bronze strip comprise the principal products and examples of these will be shown on Stand D109 against a background panorama showing all the mills in action.

Established specialists in the production of centrifugally cast phosphor bronze, JOHN HOLROYD & CO., LTD., (D105) will be making a display of spun-cast "Holfos" phosphor bronze cored bars, worm wheels made in centrifugally cast "Super-Holfos" phosphor bronze, and finish machined phosphor bronze bearing bushes. Other exhibits will include a number of standard worm reduction gear units and carbon and alloy steel forgings.

The DELTA METAL CO., LTD. (D311) were the originators of the high-speed free-cutting brasses, and samples of "Delta" and "Dixtrudo" brands of these alloys will be on show. The various "Delta" high-grade engineering bronzes will again form part of the exhibit, together with stamping rods whose consistent quality is well appreciated by the hot-stamping trade. The variety of extruded sections made by the company is very comprehensive, their size ranging from an ounce or two per foot to a half-hundredweight or more, and a few typical examples will be displayed. Other exhibits will include cast welding rods, copper rods and shaped bars for electrical work, extruded hollow rods, light sections and wire.

Other wrought non-ferrous metal products will be found on the stand of BARKER & ALLEN, LTD. (D507), where a display of nickel-silver sheet, strip, and wire will be featured, together with cupro-nickel, brass, and copper.

Exhibitors showing non-ferrous castings will include CHARLES CARR, LTD. (D604) whose display will include castings in phosphor bronze, gun-metal, aluminium bronze, etc., machined railway axle box bearings, bushes and chill-cast bars; C. & L. HILL, LTD. (D616/717), whose exhibits will include a selection of non-ferrous sand castings and chill-cast phosphor bronze bars; and KAYE ALLOY CASTINGS (D405/304) makers of pressure and gravity die castings.

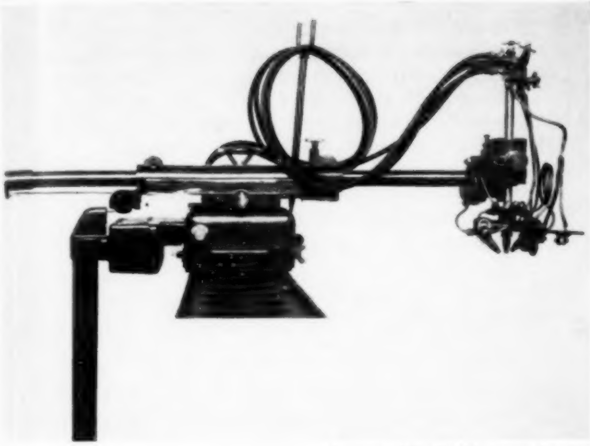
Hot die pressings in brass, copper and manganese bronze, for the engineering and allied trades will be shown by GUESTS BRASS STAMPING CO. (D732), whilst WILCOX & LINES, LTD., on Stand D414, will be showing hot pressings and stampings in brass and light alloys.

The history of aluminium production in the United Kingdom, from the establishment of the BRITISH ALUMINIUM COMPANY in 1894 and subsequent pioneering of the Highland hydro-electric schemes, down to the expansions now being carried out at the Falkirk Rolling Mills, will be the main theme of this year's British Aluminium stand, D.605. Parallel with the historical treatment of the Company's pioneering activities, the growth of applications will be demonstrated by the use of models. These models will be shown in three distinct phases of the development of the applications—prior to the Great War, between the two wars, and, finally, following the recent war.

Among the other T.I. exhibits on Stands D617/516 and D619/518, T.I. Aluminium, Ltd., will be showing a range of aluminium extrusions; aluminium strip, sheet, circles, etc.; aluminium beams and girders and examples of aluminium for structural purposes.

Welding and Cutting

Among the machines on show on the stand of SCIAKY ELECTRIC WELDING MACHINES, LTD. (C222), will be the Sciaky Three-Phase Balanced Load General Purpose Spot Welding Machine, Type SAT 75, which has undergone considerable development since it was first shown as a prototype at the B.I.F. in 1948. The outstanding feature of this machine is its welding range and flexibility. Not only can light alloys up to two equal thicknesses of $\frac{1}{8}''$ be welded, but hard brass and galvanised and other coated materials up to 12 s.w.g., hard copper up to 16 s.w.g., and thicker gauges of mild steel can all be easily welded, as pulsation control is a standard fitting of these machines. With a new phase-shifting heat-control



Courtesy of The British Oxygen Co., Ltd.

P.E.P. machine with multifloat attachment.

Courtesy of Suffolk Iron Foundry (1920), Ltd.

Sifbronze regulator.

arrangement, all the materials mentioned above can be welded in their finer gauges. One of the main advantages of the three-phase machine is, of course, the low demand on the supply mains. Other Sciaky machines shown will include the Universal Seam Welding Machine, Type RAMU 50, the Air-Operated High-Speed Stitch Welding Machine, Type SAC 25/2, and the Bench Type Air-Operated Spot Welding and Hot Riveting Machine, Type BSA 7.

A range of resistance welding machines will be shown by British Federal Welder & Machine Co., Ltd., on Stand C317. This will include their 50 kVA fully interlocked spot welding machine, pneumatically operated for single spot or air stitch welding ; a general purpose pedal operated spot welder as used in the hollow-ware trade; a fully-automatic flash welding machine ; a seam welding machine fitted with step-by-step and straight seaming control for welding thick mild steel, brass, Nimonic, etc. Full particulars will be available on the stand of a new three-phase welding machine. The machine itself will be shown if it is completed in time for the Exhibition.

A further series of resistance welding machines will be shown by Holden & Hunt, Ltd., on Stand C719/620. This will include the foot-operated spot welding machine, two air-operated spot projection welders of 30 kVA and 75 kVA, the latter being fitted with adjustable slide bottom arms. The range of butt wire welders will cover sizes from 22 s.w.g. up to ½ in. diameter. For rivet heating, two single-head, one two-head and one three-head machines will be shown suitable for use by boiler makers, constructional engineers, carriage and waggon builders. Of special interest will be the motor-driven stitch welding machine of 25 kW capacity.

Amongst the other Crompton-Parkinson exhibits, on Stand C609, will be the " Nelson Gun " for end-welding studs, pins, tubes and similar items in less than one-tenth of the time it takes to drill and tap one fixing hole. Only 5 lb. in weight and easily held in any position, it has a wide application in ferrous metal working industries.

Stud welding equipment is also featured on the Cyc-Arc stand, C218. The exhibits will comprise a Type E.1 Controller Unit and Type D Portable Hand Tool. In addition, a machine tool Type F Welder, equipped with electro-hydraulic welding head will also be demonstrated.

Besides the Model ML75 Flash Butt Welding Machine, of 60 kVA capacity, and the 161A Spot Welding Machine, of 20 kVA capacity, both general purpose machines, British Insulated Callender's Cables, Ltd. (C513) will be showing a number of resistance welding machines suitable for light work. The bench-mounted MS101C Welding Machine has been specially designed for butt-welding fine wire, ferrous and non-ferrous, and can be supplied for steel wires from 0·0108 in.–0·056 in. diameter and for copper wires from 0·0108 in.–0·048 in. diameter. For light and delicate work, such as electronic valve assembly, the M196 Spot Welding Machine will be shown, along with the B.M.I. Fine Wire Brazing Machine which is used for electrically heating the ends of fine copper wires for silver soldering. Other exhibits will include the MS301 Welding Machine for wire, and the RP25 Wire Rope Parting Machine, of which a one-third full size model will be seen in operation.

A range of seam and spot welding machines, including projection welders, will be displayed on Stand C303/204 by Siemens-Schuckert (Great Britain), Ltd. The machines exhibited will be mainly of the air-operated type, but the Company's manufacturing range also includes all the usual sizes of smaller pedal-operated machines. The seam welders can be operated either with Modulator or Ignitron control, both types being exhibited on the stand. An exhibit of special interest will be a small bench spot-welder for fine wire work.

A wide range of stainless steel electrodes will be featured on the Rockweld stand (D537). These are a recent development of the company, and, under the general name of Chromac, they include electrodes with additions of various alloying elements other than nickel and chrome. For heat-resisting steel welding, the Pyrac TT and Pyrac X rods are available. Developments continue in electrodes for welding mild steel and two new rods, Silvac and Vitrac, will be shown. The former is very easy to use, particularly in overhead welding, and can also be used for contact welding, whilst the Vitrac rod has a very high rate of deposition. Two new types of lime ferritic hydrogen controlled rods (Basac 35 and Basac 45) have been developed for (1) welding mild steel under restraint, (2) welding low alloy high tensile steels, (3) welding high-sulphur free-cutting steels, and (4)

Courtesy of Cyc-Arc, Ltd.

Portable hand tool for stud welding.

making strength welds in cast iron. Further advances in Oxyarc cutting have been made and a new gun holder will be shown, along with a range of arc welding transformers, electrode holders, etc.

ARC MANUFACTURING CO., LTD., on Stand D416, will have on show a number of welding transformers (including the lightweight Monta for repair welding and welding on site) and a diesel-driven welding generator. Arc Manufacturing have made the design of plant for inert-gas welding a special line and the 300 amp. set will be exhibited. New accessories shown will include, position- and light-gauge-welding rod holders, and a specially designed slag hammer, whilst two additions to the range of Actarc rods will comprise a rod for fast production work and one for pipe-line welding.

Part of the Owen Organisation, INVICTA ELECTRODES, LTD., will be exhibiting on the stand of the parent company, D616/717, the latest types of arc-welding electrodes.

Oxy-acetylene welding and cutting have long been the concern of THE BRITISH OXYGEN COMPANY, LTD. and the exhibits on Stand D201/100 will show the recent developments in these processes. A range of torches for welding and cutting will be displayed, together with rods and fluxes for welding, building-up and hard-facing work. Of special interest will be the P.E.P. (Plate Edge Preparation) Machine, fitted with the Multifloat attachment. With four machines running on suitable tracks, all four edges of a plate can be prepared at once. With the "Multifloat" type of machine, curves can also be cut on one or more of the plate edges while the other cuts are in progress. Argonarc welding is now a well-established process and along with the display of the newest torches and power units, demonstrations will be given on a wide range of alloys. The A.W.M.3 Automatic Argonarc Machine will also be shown.

On Stand D739/638, HANCOCK & CO. (ENGINEERS), LTD., will be demonstrating the latest Portable Circaline Mark III Cutting Machine now made in aluminium with a weight of 47 lb. Whilst lacking many of the valuable features of this machine, the Circalette, which will also be demonstrated, meets the need for a cheaper, robust machine. Other exhibits will include a U-arm machine; an electronically controlled cutter incorporating a number of improvements; a profiling machine; and machines for cutting holes in boiler shells and for cutting pipes to length. On the same stand, the associated company, WELDCRAFT, LTD., will show their acetylene generators, welding rods, cutting equipment and the "Fluxcraft" Gasfluxer.

Oxy-acetylene welding rods, fluxes and equipment, suitable for all types of materials will be featured by SUFFOLK IRON FOUNDRY (1920), LTD., on Stand D620. Of special interest will be the new "Sifbronze" Regulator, for use with various gases.

For delicate brazing operations the lightweight Flamemaster Hand Torch shown by CHANCE BROTHERS, LTD., on Stand C.619 will be of interest.

Rolls for Rolling Mills

The imposition of rigid specification for a rolled product in the ready-to-use and true-to-gauge condition, has necessitated rolls possessing the ideal surface structure, to suit a wide range of product, whilst the introduction of continuous rolling with the attendant changes in bearing design has led to radical revision of tolerance limits. The continued need for improvement

Courtesy of The Fordath Engineering Co., Ltd.

Fordath Multiplunger core machine.

has presented new and difficult problems to the roll maker. Such opposed characteristics as hardness and toughness, wear resistance and heat resistance, rigidity and flexibility, must be combined to give optimum results. A wide range of rolls will be exhibited by THE BRITISH ROLLMAKERS CORPORATION, LTD., on Stand D517, together with photographs illustrating some of the largest rolls made for the rolling of plates.

Foundry Equipment

Materials and equipment for the production of cores will comprise the exhibits of THE FORDATH ENGINEERING CO., LTD. (D146), and will include a selection of cores, showing the latest techniques used in the automobile and aircraft casting industry, which will be made using Fordath "Glyso" and "Permol" binding compounds. Three models of the Fordath sand-mixing machines will be on view, together with the Fordath Rotary Core Making Machine, the Fordath Multiplunger Core Machine, and the CorALL Core Blowing machine, the last two being completely new machines.

A newcomer to Castle Bromwich, FOUNDRY EQUIPMENT, LTD., (D322) will be showing two of their sand-rammers, the Minor and the Junior, a new machine which will fill the gap between the Minor and the No. 1

Linslade Rammer. Both the machines shown are designed specially for the production of small to medium jobbing work in foundries, and also for core production.

On Stand B601, COLIN STEWART, LTD., and associated companies, who are concerned with the fine grinding of such non-metallic minerals as silica, bentonite, magnesite, zircon, talc, sillimanite, fluorspar, etc., will have at least two products of interest to foundrymen on show. These are ground silica and bentonite. The latter is from a soft-currency source and laboratory tests and extended works trials have shown it to be equal to the American material.

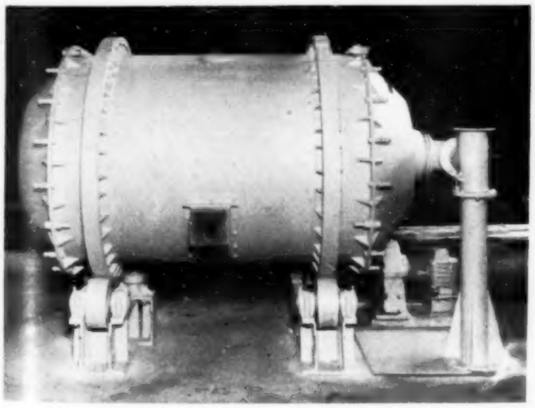
A clay bonding material, Fulbond, made by THE FULLERS' EARTH UNION, LTD., will be featured on Stand D117, along with castings made in sands bonded with it.

Various items of foundry interest will be displayed on the stand of THOS. W. WARD, LTD., (Outdoor 1360), who are sole selling agents for the Polford range of foundry plant.

Space will not permit the showing of any of the large crucible furnaces by THE MORGAN CRUCIBLE CO., LTD. (D305/204), but one item of special interest on the stand will be the Morgan Miniature Crucible Furnace (Gas-Fired Model) which is a modification of the original paraffin furnace which achieved such success in the 1950 B.I.F. The new model is for use where gas is available, or where it is not desirable to handle paraffin. A display of 'Salamander' Plumbago Ware will include crucibles, launders, knock-off riser plates, nozzles, bricks, etc.

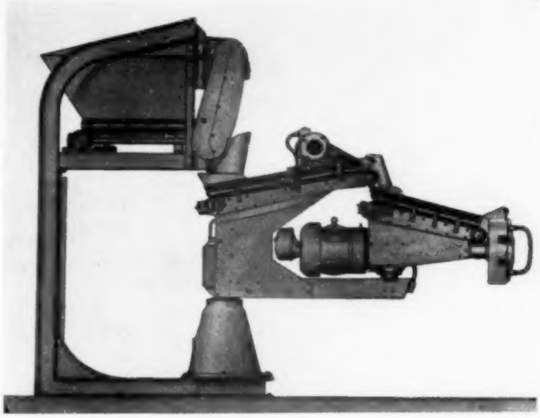
Of special interest to steel founders will be the new fettling bench exhibited by K. & L. STEELFOUNDERS AND ENGINEERS, LTD., in the "600" Pavilion (Outdoor 1332). It has been designed with the object of mitigating those conditions, connected with the dressing of steel castings, which are liable to cause pneumoconiosis.

Suitable for foundry and other uses, considerable interest will be found in the metal melting furnaces which will be shown by the MONOMETER MANUFACTURING CO., LTD., on Stand D731. These will include the latest design oil-fired fully-mechanised continuous rotary furnace, complete with retractable end flue, for melting ferrous and non-ferrous metals; semi-rotary oil or gas-fired melting furnaces for non-ferrous metals; a cylindrical oil-fired travelling holding ladle for ensuring the availability of a continuous supply of hot metal for the casting bay; a vertical 3-ton capacity valve-outlet melting furnace for feeding presses for the production of lead pipe and cable sheathing; and bale-out, lift-out, and tilting crucible furnaces.



Courtesy of Monometer Manufacturing Co., Ltd.

Oil fired, fully mechanised, continuous rotary furnace.



Courtesy of Foundry Equipment, Ltd.

Junior sandrammer.

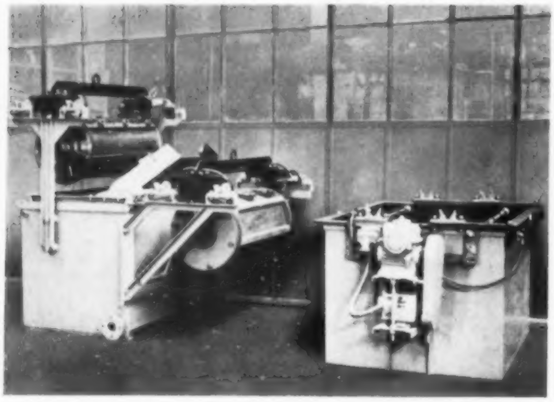
Under power, to show the operation, an E.M.B. No. 6 Cold Chamber Die-casting Machine will be seen on Stand D240 (E.M.B. Co., LTD.). This is a small pneumatically operated machine for producing small die castings such as instrument details, etc. The high injection speed enables small, thin castings to be made with a perfect finish. The die casting machine display by ALFRED HERBERT, LTD. (D321/218) will feature the M55A Model.

For the purpose of sand cleaning, foundrymen will be interested in the various types of magnetic separator shown on the stands of the RAPID MAGNETIC MACHINES, LTD. (C421) and ELECTROMAGNETS, LTD. (C605).

Tubes and Pipes

On the TUBE INVESTMENTS' stands, D617/516 and D619/518, there will be a display of the products of the constituent companies, including tubes, rolled metal sections and aluminium sheet and sections. Apart from the show of the general range of seamless and welded tubes in steel, stainless steel and aluminium alloys—with an indication of the wide variety of products in the making of which they are used—there will be a special display of small tubes, including the new record "smallest tube in the world," and many small bore composite and non-circular tubes which are used in scientific research and new industrial processes. T.I. will also be showing high pressure cylinders; a series of cold-rolled metal sections for the building industry, including nailable steel joists, aluminium beams and girders; tubular forgings; and stainless steel tubes and fittings for the dairy industries.

STEWARTS & LLOYDS, LTD., with subsidiary and associated companies, will again be exhibiting a wide range of their tube products. In the Engineering Group, a reception stand, D511/408, staffed by representatives of the Company, is at the service of visitors, for all enquiries relating to the exhibits and trade and technical matters generally. This stand features a section of a 72 in. sheathed and lined steel main, into which five panels have been inserted, each containing a colour transparency illustrating stages in the manu-



Courtesy of Electro-Chemical Engineering Co., Ltd.

Storage and transfer unit and EFCO-Udylite fully immersed horizontal plating barrel.

facture, production and laying of large diameter steel mains; examples of coils and cold rolled steel strip; and a series of illuminated photographs depicting a complete range of tubular steel lighting columns manufactured by S & L. The D Outdoor Stand comprises a steel building housing a comprehensive range of the Company's products, including steel tubes and fittings, examples of protective linings and sheathings, tubular steel coils, hot and cold rolled steel strip, foundry and basic pig irons, iron and steel castings, and steel and tube works' by-products.

The exhibits of Aiton & Co., Ltd., specialists in complete power station pipework installations, on Stand D608, will follow the same lines as in previous years. They will include a chrome-molybdenum steel high pressure steam header, examples of creased and corrugated bends, examples of Corwell and butt-welded pipe joints, high pressure steam traps and stainless steel bellows expansion joints.

On Stand D618, Serck Tubes, Ltd., will have a display showing cut lengths of solid drawn tubing in the non-ferrous metals and the purposes for which these are used. The Company's main speciality is high speed turning and machining brass.

No details are to hand at the time of going to press concerning the exhibits of the Yorkshire Copper Works, Ltd., but, no doubt, a wide range of non-ferrous tubing, in which the company specialises, will be displayed on Stand B723/634.

Wire

The London Electric Wire Company and Smiths Ltd., and its Associated Companies, Frederick Smith & Company, The Liverpool Electric Cable Co., Ltd., and Vactite Wire Co., Ltd., will display bare and insulated conductors for all electrical purposes on Stand C717. These include the well-known "Lewcos" products—cotton, silk, paper, enamel, Lewmex, Lewmexglass and Lewbestos insulated wires and strips; "Anacos" bare copper and copper alloy wires, strips, strand, sections and forgings; power-transmission lines, trolley wires and telegraph and telephone line wires; L.E.C. rubber and paper insulated cables for use in mines, quarries, ships, factories, railways; underground power cables, and domestic flexibles. Eureka and nickel-chrome resistance wires and tapes, molybdenum rods wires and tapes, and special wires for the lamp and radio valve industries will also be on view.

An interesting exhibit on Stand D607 (John Rigby & Sons, Ltd.) will be their "Tectic" hardened and tempered duct and drain rodding, which will be of special interest to cable and telephone engineers, etc. Other products on show will include all classes and finishes of steel wire, together with special sections, and brass and steel precision-drawn pinion rods for the clock, meter, instrument and toy trades.

The drawn products shown by United Wire Works (Birmingham), Ltd., on Stand D215, will be on the non-ferrous side. Besides round and shaped wire, rods, and strip in brass, phosphor bronze, copper and nickel silver, high speed turning and screwing brass and hot stamping brass will be shown in rounds, squares and hexagons.

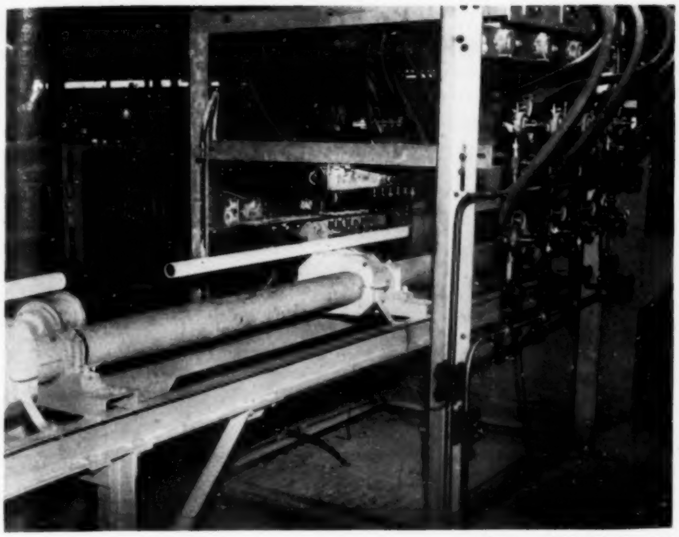
Other firms displaying wire and wire products will include Lee of Sheffield, Ltd. (D528) who will be showing high-grade steel wire and stainless steel wire; Padley & Venables, Ltd. (Stand D525/422), stainless steel wire; Richard Johnson & Nephew, Ltd. (Stands B417 and 322), ferrous and non-ferrous wires; Rylands Bros., Ltd., Warrington (Stand A528), ferrous and non-ferrous wires, fencing, nails and various wire products; The Whitecross Co., Ltd. (Stand A518), industrial and agricultural wires, both ferrous and non-ferrous wire products and wire ropes for mining, shipping and engineering purposes.

Electroplating

The examples of "Fescolising" exhibited on Stand D652 give some indication of the capacity of the Fescol, Ltd., plants situated throughout the country. Both small and large components are represented, although it is not possible, owing to restrictions of space on the stand, to show an example of the largest type of work which can be handled. An effort has been made to cover the range of the applications of the Fescol process to industry generally, including the treatment of components for the prevention of corrosion and/or wear, and the salvage of worn and incorrectly machined parts.

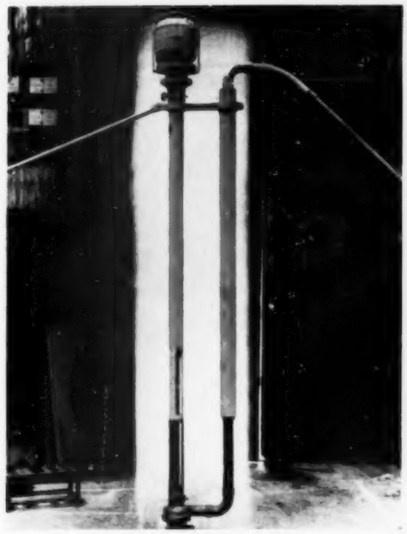
A number of items of plating equipment will be shown by W. Canning & Co., Ltd., on Stand D207/106. These will include a semi-automatic, totally immersed, barrelling unit for nickel plating; a thousand gallon totally enclosed filtration unit; a current density panel for maintaining automatically the voltage/current relationship; the "Automax" chrome barrel; a bottom emptying centrifugal drier with a work basket of some 7–8 gallons capacity; a Hector barrel representing the latest developments in totally submerged plating barrels, which may be used for the deposition of most common metals other than chromium; and the Canning centrifugal lacquering machine. Other exhibits will include a motor generator set, rectifier, resistance boards and a comprehensive selection of materials such as plating salts, etc. On Stand D211, the polishing equipment division of the same company will be displaying a return type straight line conveyor type polishing machine, a screw head polishing machine, a No. 2718 centreless abrasive band machine, an attachment for polishing irregular-shaped articles, and a comprehensive range of polishing mops, brushes and materials for the finishing of metals.

The main exhibit of the Electro-Chemical Engineering Co., Ltd., on Stand C611, will be a typical Efco-



Courtesy of Metallisation, Ltd.

Fully automatic spraying machine for steel tubes.



Courtesy of Thompson Bros. (Bilston), Ltd

Vertical type spelter pump for use with fluid metals.

Udylite barrel plating production line. The equipment shown will comprise a loading station, a tank in which the work is tumble-cleaned and a special cleaning cylinder, followed by storage and transfer unit. This is designed to receive work from the cleaning cylinder and to transfer it to the plating cylinder as required, a constant flow of work thus being assured.

R. Cruickshank, Ltd., on Stand D226, will be concentrating mainly on new and improved designs of many of their standard items such as centrifuges, plating barrels, etc. An up-to-date suds barrel is also being shown together with loading equipment and a frit grader. A new type of agitation unit for swill tanks without the use of compressed air and a complete periodic reversal unit will be featured prominently, together with polishing motors, rectifiers, etc. The usual range of polishing mops and compositions, brushes and ancillary equipment will also be on view.

Of particular interest to the plating trade, on Stand D434, will be the display by Girdlestone Pumps, Ltd., of diaphragm pumps for corrosive and abrasive fluids.

Other Surface Treatments

First in the field with automatic metal spraying, Metallisation, Ltd. (Outdoor 1246/1347), in support of their claim to be world leaders in the technique, will have on show a fully automatic metal spraying machine capable of spraying 10,000 ft. of steel tubing with zinc or aluminium per day.

Exhibited for the first time on Stand D635 (Thompson Brothers (Bilston) Ltd.), will be a pump for the rapid removal of hot fluid spelter from a galvanising bath. The output of the pump, as deduced from recent tests, is approximately 30 tons of spelter in 15 minutes. Other galvanising plant on show will include a centre drive centrifugal machine for use with hot-dip galvanising whilst a complete galvanising plant recently supplied by the company will be represented by a true-to-scale model

Examples of architectural ironwork, rust-proofed by the sherardising process (coating with zinc by heating in zinc powder) will be displayed on Stand B724 by the Zinc Alloy Rust-Proofing Co., Ltd. The company does not manufacture architectural ironwork but specialises in carrying out sherardising for the makers of casements, metal trim, screws, nails, etc.

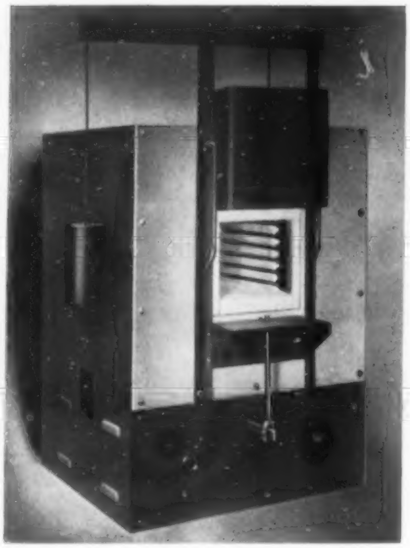
A similar process in which aluminium powder is used instead of zinc, is calorising. The virtue of this treatment is the high degree of scale-resistance conferred on steel parts thereby and on Stand D407/306, The Calorising Corporation of Great Britain, Ltd., will be exhibiting calorised solid pressed steel heat treatment containers for cyanide, salt, lead, casehardening and annealing, together with pyrometer sheaths, air heater tubes, etc.

Follsain-Wycliffe Foundries, Ltd., on Stand D709, will be showing their Wyprest cyanide pots, which are pressed from a composite material consisting of a layer of mild steel with which is rolled a layer of nickel-chromium heat-resisting steel of some 20% of the total thickness. Service reports indicate that long life is to be expected from these pots. A comprehensive range of carburising boxes in both E.V. nickel-chromium heat-resisting steel and in mild steel Penetral treated which renders them resistant to oxidation for temperatures up to 1,000° C.

Furnaces and Refractories

Displayed on Stand C303/204, will be a small number of muffle furnaces, necessarily a very small selection of the wide range of Siemens-Schuckert furnaces, which includes pit furnaces, hood furnaces, continuous furnaces, etc. Of special interest will be the high-temperature furnaces for operating at furnace chamber temperatures of 1,350° C. These furnaces are equipped with " Silit " heating rods which give trouble-free continuous service at temperatures of 1,400° C. and beyond.

One of the latest models in the Radyne range of induction heating equipment, the C25/A, a 3 kW set will be shown by Radio-Heaters, Ltd., on Stand C219. In this model, no access need be obtained to the lower



Courtesy of Siemens-Schuckert (Gt. Britain), Ltd.

Type W.M. 10/7/6 muffle furnace.

Courtesy of Applied High Frequency, Ltd.

25 kW induction heater.

front of the generator, a fact which makes the set particularly suitable for use with mechanical handling gear. The equipment incorporates a number of patented features which the makers claim enable it to perform operations never previously possible on a set of this rating.

Applied High Frequency, Ltd., will be showing a range of high frequency induction heating equipment, on Stand D416, which includes 1 kW, 7½kW and 25 kW sets for various soldering, brazing, local hardening and annealing applications, and which can also be used for various other applications, including the melting of small batch quantities of ferrous, non-ferrous, and precious metals.

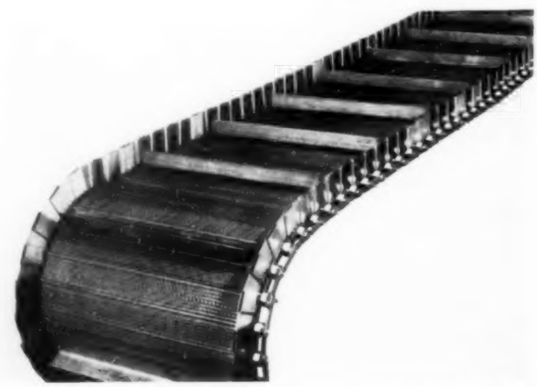
For hardening, annealing, tempering and similar processes requiring temperatures up to 1,200° C., Barlow-Whitney, Ltd., will be showing a small general purpose B-W furnace. These furnaces are made in several standard sizes and are complete with adjustable regulator, indicator, etc.

Centrepiece of the Gas Council Stand (D639/538) will be a full-size bogie furnace (Dowson and Mason Gas Plant Co., Ltd.) of the type used for annealing and stress relieving, whilst for heating small parts for forging, an automatically controlled slot forge furnace (Thermic Equipment and Engineering Co., Ltd.), will be shown. A small portable furnace by the latter company will demonstrate the use of gas firing for the rapid heating of steel sections prior to bedding. Shown in the form of a model, will be an Incandescent Heat radiant tube heated roller hearth conveyor furnace, suitable for the bright annealing of both ferrous and non-ferrous metals, in the form of pressings and strip, wire, sheet and tubes, at temperatures up to 1,000° C.

Although detailed advance information is not available concerning The Incandescent Group (C726/628) we are assured that visitors will find there, not only interesting exhibits, but an extremely fascinating method of putting them across. Of the constituent companies, The Incandescent Heat Co., Ltd., are makers of a wide range of gas-fired metallurgical furnaces, foundry equipment, and plant for galvanising and enamelling, while Controlled Heat and Air, Ltd., specialise in continuous and static ovens of all types, spray booths, and air treatment plants. The range of gas-fired furnaces made by The Incandescent Heat Co., Ltd., has its counterpart on the electrical side in the products of Metalectric Furnaces, Ltd., who also make direct-arc steel melting furnaces, induction heating equipment and dielectric core-drying plant. Of the remaining companies, Metal Porcelains, Ltd., supply complete vitreous enamelling equipment and materials, while Selas Gas and Engineering Co., Ltd., manufacture industrial heating equipment for all purposes, including a wide range of burners.

An important part of a continuous furnace is the means for transporting components through the furnace, and, on Stand D150, George Lane & Sons, Ltd., will be showing wire conveyor belts in all forms and appropriate alloys for continuous furnaces operating up to 1,150° C. Other types of belting, in particular the Integral Chain Edge Wire Conveyor Belt, which provides a positive drive, are manufactured for quench tanks, washing, drying, any corrosive applications, and general conveyance purposes.

On the refractories side, the display of John G. Stein & Co., Ltd., on Stand D313, will consist essentially of samples of bricks from their extensive range. This will include silica bricks for open-hearth purposes, both of normal quality and Super Duty; fire bricks ranging in alumina content from 32–44%; high alumina bricks containing 50–90% alumina, and including special bricks such as Stein Mullite 73% alumina, and Stein Sillimanite 62% alumina; and basic refractories, including straight magnesite, chrome magnesite and chrome. Also on show will be samples of refractory cements and of ramming and casting refractories.



Courtesy of George Lane & Sons, Ltd.

Chain edge quench tank wire conveyor belt fitted with baffles and side plates, made throughout in stainless steel for corrosive conditions.

The usual range of P.B. SILLIMANITE refractories will be shown on Stand C622, in the form of bricks, tiles, blocks, etc., for furnace construction, together with many special shapes specially suitable for electric furnaces. Ramming mixtures for oil or gas-fired crucible furnaces and for rocking-arc and rocking-resistance types of electric melting furnaces will be shown, together with refractory cements and patching mixtures and the " Pebesil " double coating process for the protection of insulation bricks. Other exhibits will include laboratory ware in high-temperature-resisting Mullitic porcelain materials, and refractories for precision casting work.

On the Stand of J. H. SANKEY & Co., LTD., (B405), Pyruma, Siluma and Aluma fire cement will be displayed along with Sankey's super acid resisting cement, and various types of fire bricks and acid resisting bricks.

The display of refractories featured on Stand D305/204 by the MORGAN CRUCIBLE Co., LTD., will show the wide diversity of shapes and materials available. The range of refractory bricks will include a selection of grades for use in heat treatment furnaces, boiler settings, oil stills, steel ladles, etc., made by Morgan's associate, the DOUGLAS FIREBRICK Co., LTD. Of special interest will be the display of Carblox corrugated hearth blocks and standard shapes for blast furnaces.

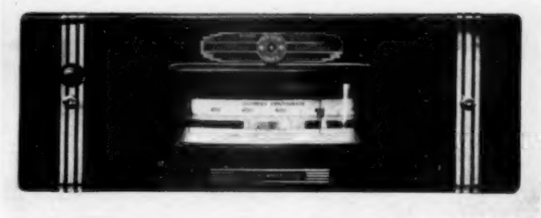
Graphite electrodes for electric furnace operation, graphite anodes for electrolytic cell operation and amorphous carbon electrodes for electric arc furnace operation, will be among the exhibits featured by BRITISH ACHESON ELECTRODES, LTD., on Stand C319. Others will include carbon blocks for furnace linings, crucibles, blocks, resistor spirals, mould stool inserts for metallurgical work and a number of other examples of the use of graphite in chemical and electrical work.

Temperature Measurement and Control

The ETHER exhibits this year, on Stand C700, feature the Ether-Wheelco range of electronically-operated temperature controllers, which are manufactured under licence from the Wheelco Instrument Co., of Chicago. The Ether-Wheelco Proportioning Controller, Model 251P, gives a simple proportional control and is particularly suitable for electric furnace use, whilst the Ether-Gordon " Xactline " Anticipatory Control Device is used in conjunction with the Ether-Wheelco " Capacitrol " in order to eliminate " hunting " in a control variable due to thermal-capacity. The " Flame-otrol " will be exhibited with electrodes for use in conjunction with gas-fired apparatus, and with a photocell for oil-fired apparatus. A further electronic instrument on show will be the " Widestrip " Potentiometer, which, working in conjunction with resistance bulbs, will measure the temperature of the Exhibition Hall itself. The exhibit will be completed by a display of molten metal pyrometers, surface pyrometers, optical pyrometers and Ether " Indicorder " continuous chart recording pyrometers.

At the time of going to press, no details have been received concerning the exhibits of ELLIOTT BROTHERS (LONDON), LTD., who for more than 150 years have been in the instrument trade. Besides straightforward electrical measuring instruments, it is expected that various items of temperature measuring and control equipment will be on show. (C320).

Tem-Con, the temperature control system developed by P.A.M., LTD., will be demonstrated on the stand of



Courtesy of Ether, Ltd.

The Ether-Wheelco proportioning controller.

the parent company, THE SOUTHERN AREAS ELECTRIC CORPORATION, LTD. (C416), where industrial applications will be represented by a press platen, an injection moulding machine cylinder, and an extruder barrel.

Occupying their usual stand (C722), LONDEX, LTD., will present their range of relays, contactors, process timers, level and flow controllers, photo-electric equipment, and pressure and vacuum switches. Among the new instruments shown will be an Energy Regulator and " Variable On/Off Ratio " Timer, Type VM/TS, which can be used for temperature control.

Based on differential expansion, a wide range of thermostats will be shown by ROBERT MACLAREN & Co., LTD., on Stand C325. There are many thermostats on the market for use at relatively low temperatures, but relatively few for temperatures as high as 1,000° C. Especial interest is attached, therefore, to the FN Standard Pattern High Temperature Thermostat for use at temperatures between 300° and 1,100° C.

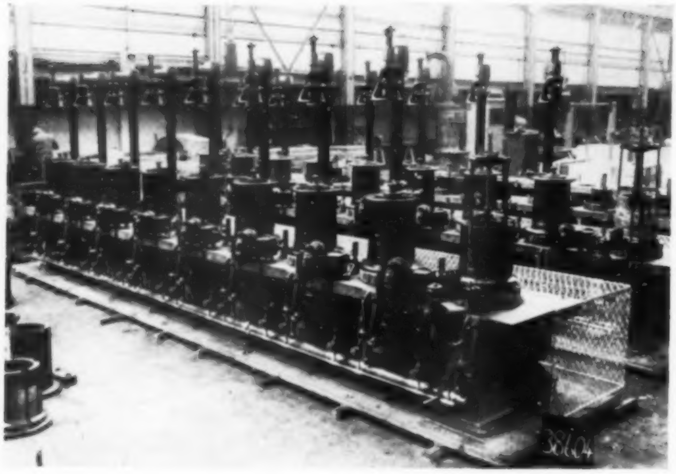
For the purposes of remote indication, the "Desynn" system shown by SMITHS INDUSTRIAL INSTRUMENTS, LTD., on Stand D727, will be of interest. The transmitter and indicator are connected electrically and distant indication of pressure, displacement, temperature, fluid level, etc., is possible by this means.

A comprehensive range of domestic and industrial temperature control equipment will be shown by the RHEOSTATIC Co., LTD., (C500), including thermostats, gas valves and gas safety devices.

Other temperature indicating, recording and controlling equipment will be found on the stand of KELVIN & HUGHES, LTD. (D626) whose exhibits are referred to in greater detail in the section headed " Miscellaneous."

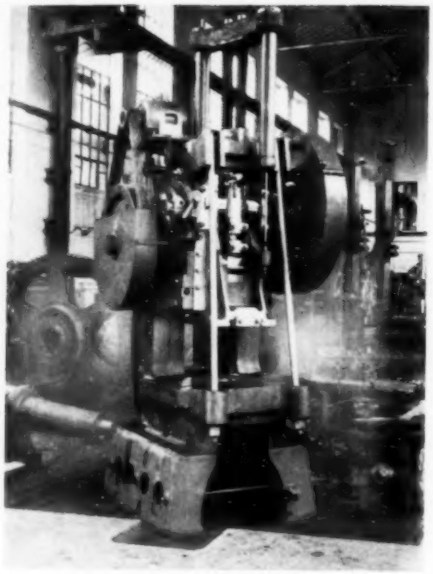
Machine Tools

Although the machine tool trade in general is not represented at the Fair, there will be several items of equipment of interest to the metal working trade on show. SIR JAMES FARMER NORTON & Co., LTD., will be showing, on Stand D167, selections from their wide range of products in the metal production machinery field, and these will include the TF 3B 21-Die Continuous Wire Drawing Machine for producing high carbon steel, mild steel and non-ferrous wires at speeds up to 4,000 ft. per minute ; the G.M.S. 9 Block Accumulation Type Machine for speeds up to 1,500 ft. per minute, and a Single Block Wire Drawing machine suitable for all purposes. In conjunction with the last-named, will be shown a new type of bobbin winder for use with the G.M.1 and G.M.2 machines when wire has to be wound directly on to spools for use in the rope making industry. Other exhibits will include a roller flattening and cutting



Courtesy of Sir James Farmer Norton & Co., Ltd.

G.M.S. Wire drawing machine.

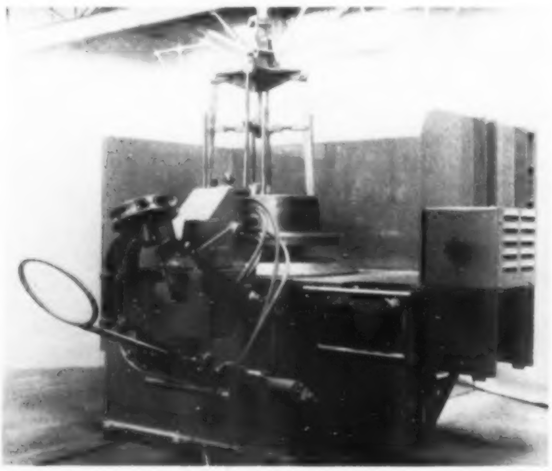


Courtesy of Taylor & Challen, Ltd.

Open-front press of 100 ton capacity, Type 1664.

off machine, incorporating a patented arrangement of diminishing rollers which, it is claimed, ensures a much better effect than can be obtained on machines of the constant diameter roller type. On the same stand, Anglardia, Ltd., will be exhibiting a selection of their tungsten carbide and diamond impregnated products, whilst Wire Drawing Dies (Manchester), Ltd., will display a range of diamond dies, tungsten carbide dies, a selection of blocks and mandrels, and tungsten-carbide-faced rollers for the flattening of wire and strip.

The wire drawing equipment to be found on Stand C329/228 (Marshall Richards Machine Co., Ltd.) will include two vertical bull blocks of very heavy capacity, the V20 having a maximum available pull of 20,000 lb., and the V16 of 16,000 lb. Interchangeable drawing blocks for these machines, with cast steel renewable wearing inserts, will also be exhibited. The Company manufactures a wide range of medium capacity vertical bull blocks, and a double-deck block,



Courtesy of Marshall Richards Machine Co., Ltd.

Vertical bull wire-drawing block, of medium capacity.

to enable two-holing to be done when desired, and capable of drawing mild steel from inlets of approximately ½ in. diameter, will be on show.

An inexpensive hydraulic servo equipment which enables most shapes to be machined quickly and accurately to the profile of a master template or sample workpiece will be shown by Metropolitan-Vickers Electrical Co., Ltd., on Stand C510.

On Stand D415, Taylor & Challen, Ltd., will have on show four power presses. The type 1664, 100 ton capacity, Open-Front Press can accommodate tools of large overall dimensions, and runs at 35 strokes per minute, being driven by a 10 h.p. motor. A popular press for deep-drawn articles in sheet steel, brass or aluminium, is the Double Action Drawing Press, Size, 4½, which will admit a blank up to 18 in. diameter. The remaining two presses are an Automatic Double Action Cutting and Drawing Press, and a High Speed Armature Disc Notching Press, Type 1558.

Customers demands permitting, Turner Bros. (Birmingham), Ltd., hope to show on Stand D512, a 70 ton Geared Power Press, a Universal Saw Tooth Notching Machine and a special All-Purpose Horizontal Press.

A new addition to the range of Bliss presses, on Stand D603, will be a No. 6100 High Production Press. This has a maximum capacity of 130 tons, rated for fine blanking dies of 100 tons, a standard stroke of 2 in. (maximum 3 in.), a closed height of 8 in., and normally operates at 40–150 strokes per minute. Other Bliss exhibits will include an automatic can-body maker, a gang slitting machine and an inclinable power press.

On the Wilkins & Mitchell Stand (D600) will be exhibited a two point suspension fully eccentric type, 150 ton capacity, power press, which is complete with two of the latest type self-contained cushion units requiring no separate receiver tanks, and is, therefore, suitable for both forming and blanking work. It has been specially developed for multi-die set-ups.

In addition to a Mills Oilaulic 80-ton Vertical Press, JOHN MILLS & CO. (LLANIDLOES), LTD. (Stand D337), intend to exhibit a new addition to their range. This is a Mills Oilaulic 6-ton Press for bench mounting. This machine is ideal for innumerable applications in fitting and assembly shops.

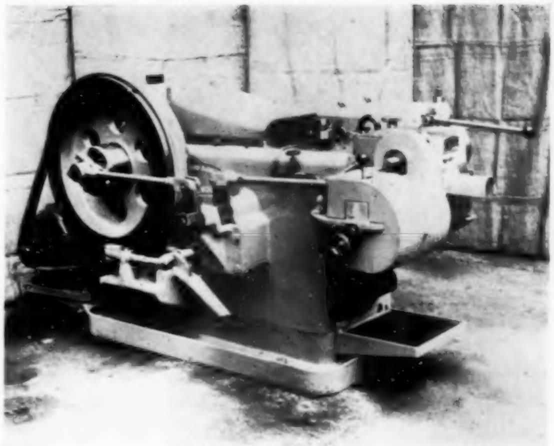
A number of new presses will be seen on the Stand of JOSEPH RHODES & SONS, LTD. (D325). These will include a patent fluid driven bending press offering advantages over the standard all-mechanical types; an open-gap type power press; a double sided power press fitted with a patent die to cut and form deep stampings at one stroke, and a small inclinable press fitted with a patent "Whip Sleeve" punch.

On Stand D159, The ROCKWELL MACHINE TOOL CO., will be showing selected items from the range of British-built U.S. press room equipment, as well as a Sentinel 25 ton Unit Press. This will be arranged as a completely automatic unit with slide feed, straightener, stock oiler and wiper and uncoiling reel. Other exhibits will include a selection of stock reels, power driven straightener, and two entirely new items, the first being an automatic coil cradle arranged so as to allow automatic uncoiling by means of a mercury switch loop control, and the second, a newly-designed scrap chopper, the cutter blades of which are usable on four different edges.

In the 600 Group Pavilion (1332), GEORGE COHEN SONS & CO., LTD., will be exhibiting Weybridge Rotary Cutting and Slitting Shears (light and medium gauge models) and a Coborn-Wadley Combined Punching, Shearing, Cropping and Notching Machine, Type DEPS 24.

A 16 in. Airdraulic Broaching Press and a 7 ton Flexipress Straightening Machine will be seen on Stand D240 (E.M.B. Co., LTD.). The latter is a machine of great sensitivity and a patented device not only checks straightness but also registers the amount of reverse bend applied.

GREENWOOD & BATLEY, LTD. (D235) will demonstrate a high speed cold forging machine for cold upsetting from wire, bolts, rivets, etc. This machine is a new design which includes several established features, but with modifications to obtain higher speeds. It is designed for double-blow work and runs at 300 r.p.m., giving an output of 150 components per minute.



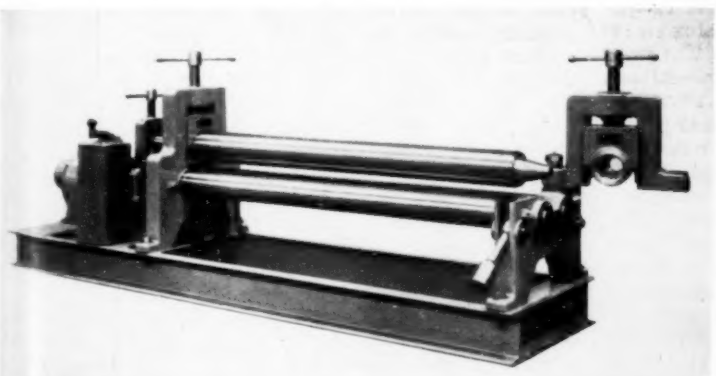
Courtesy of Greenwood & Batley, Ltd.

High speed cold forging machine

J. P. UDAL (D630) have specialised in the guarding of power and hydraulic presses in line with official and customers' requirements for more than 20 years. Various types of guard will be shown under working conditions; these will include the Fastrip series, whose use has been shown by experience to permit substantially higher output rates as well as increasing the safety factor as compared with hand-operated interlock guards.

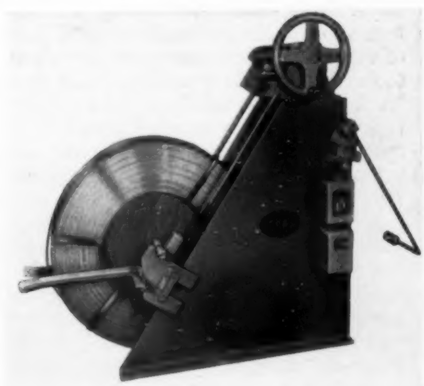
All the metal cutting machines on the stand of THE MIDLAND SAW & TOOL CO., LTD. (B228) will be running and capable of demonstration. Shown for the first time will be a 36 in. 8-speed Bandsaw Machine, for cutting aluminium, bronze, phosphor bronze, gun-metal, brass and aluminium alloys. There will also be on show the A.T.C. Toolroom Bandsaw Machine, with saw welder incorporated; the A.T. Toolroom Bandsaw Machine, with saw brazer incorporated; a 36 in. Variable High-speed Bandsaw Machine for sheet metal; and an Overhead Cut-Off Machine for extruded aluminium sections.

The machines displayed by F. J. EDWARDS, LTD., on Stand D411 will include four new ones of particular interest to the sheet metal working industry, while a new inclinable power press and a bar-cropping machine



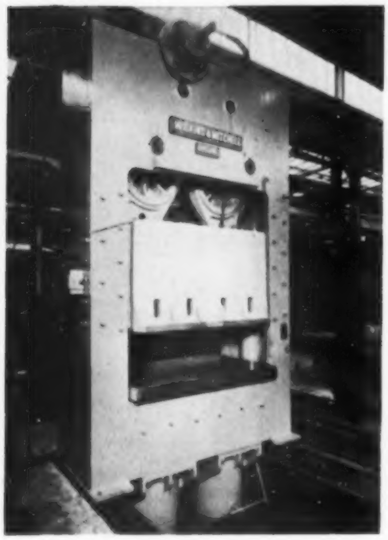
Courtesy of F. J. Edwards & Co., Ltd.

Besco production plate bending rolls, Type N.



Courtesy of Rockwell Machine Tool Co., Ltd.

New type coil cradle.



Courtesy of Wilkins & Mitchell, Ltd.

100-ton capacity power press.

Courtesy of Hills (West Bromwich), Ltd.

Factory ventilation by roof ventilating shutters.

should prove of interest to those concerned with press work and structural engineering respectively. The sheet metal machines will include two guillotine shearing machines, a set of plate-bending rolls, and a circling shear.

Other metal working machinery will be exhibited by Thos. W. Ward, Ltd., who are occupying Stands D719 and Outdoor 1360.

Specialists in machines for breaking, crushing, pulverising and grinding friable material, British Jeffrey-Diamond, Ltd. (D526) intend to display a selection of machines from current production that will be representative of the B. J-D. range. They will include a 42 in. × 36 in. Flextooth Crusher ; a 15 in. × 8 in. Rigid Hammer Crusher ; a 36 in × 36 in. Swing Hammer Pulveriser ; a 15 in × 8 in. " Atomill " Fine Grinder ; and a B. J-D. " Microid Atomill."

Small Tools and Tool Steels

The die steel exhibit on the Edgar Allen Stand (D534), will indicate the successful development of steels for pressure die-casting aluminium and copper-base alloys, and advances in the more economical extrusion of these alloys by alternative hot die steels. The small tools will include standard, form ground special and hand ground special Stag Major Superweld butt-welded tools, high speed steel solid tools of various form ground special types, Athyweld deposit-welded tools, the principal interesting items being roll turners' tools in 10/12% cobalt steel having a minimum Rockwell hardness of C.65, form tools in the same material, and various deposit-welded woodworking blades. There will also be a range of Stag Major high speed steel tool-holder bits, both round and square, Stag Major special design taper shank twist drills for drilling manganese and high tensile steels, and 18% tungsten jobbers and taper shank drills.

Turton Brothers and Matthews, Ltd. (D413), will show their range of small tools and tool steels, including twist drills, butt-welded tools, shear blades, coil springs, permanent magnets and tool steels. It is hoped to have an interesting exhibit in the form of tools loaned by customers, showing the use of C.M.D. Die Steel for blanking and forming Stalloy, Nimonic and stainless steels.

The products of the Openshaw works of English Steel Corporation, Ltd., shown on D541/438, will include a comprehensive display of engineers' tools, including twist drills, reamers (solid and expanding), taps, dies and chasers, gear cutters, hobs, broaches, milling cutters, side and face and slotting cutters, end mills, slot drills, quick change chucks, lathe tools and boring cutters, chisels and rivet snaps, files and rasps, and hacksaws.

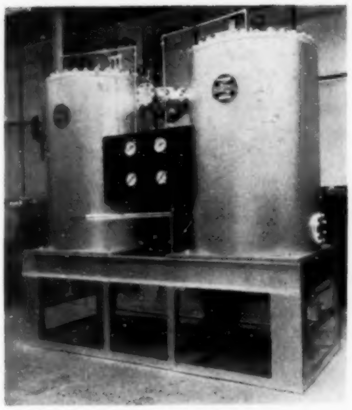
The measuring equipment to be seen on the stand of Alfred Herbert, Ltd. (D321/218), will include the range of Hilger projectors, and the Sigma Automatic and Semi-Automatic Multi-Dimension Inspection Machines. Small tools will include dieheads, ground thread tips, thread rolling dies and the Herbert range of carbide-tipped face milling cutters. Fellows-Orcut gear shaper cutters and the Microbore adjustable precision boring units will also be exhibited.

Since bars of tool steel do not lend themselves to display, the layout on Stand D234 (Richd. W. Carr & Co., Ltd) will take the form of die-sets and other types of tool made from different qualities of " Motor " brand tool steels, together with finished products produced by them. A number of steels suitable for pressure die casting will be shown, different qualities being recommended for brass, aluminium and zinc alloys. Other steels displayed will include types suitable for hot working, cold working and machining. A range of engineers' small tools will complete the exhibit.

The complete range of the products of Wolf Electric Tools, Ltd., will be shown on Stand C603 and will include two machines new to the B.I.F. These are the 10 in. portable all ball-bearing Electric Saw, Model R.S.10, and the H.D.1. Building and Maintenance. Hammer Kits. The display will be completed by a

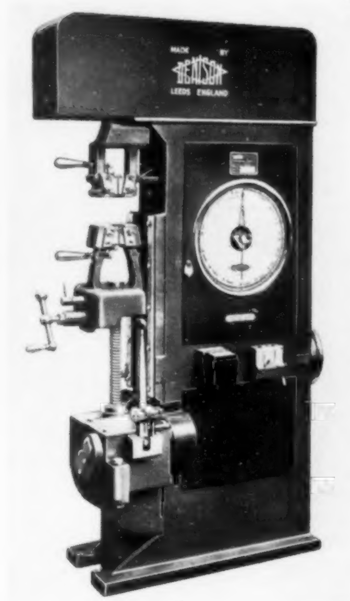
Courtesy of Kelvin & Hughes (Industrial), Ltd.

An ultrasonic flaw detector.



Courtesy of Birlec, Ltd.

A B.W.C. 1500 Birlec Lectrodryer.



Courtesy of Samuel Denison & Son, Ltd.

Model T.42 dial indicating tensile testing machine.

varied selection of portable electric drills, screwdrivers, grinders, polishers, sanders, blowers, solderguns, etc

On the DAVID BROWN stand (D345) a representative selection of gear cutting tools of all types, together with gear measuring instruments, made by THE DAVID BROWN TOOL COMPANY will be exhibited along with patent floating reamers, with micrometer adjustment, and typical jigs and fixtures.

Other firms exhibiting tools will include DELORO STELLITE, LTD. (D402); THOMAS CHATWIN & CO., LTD., and JOHN BROOKS (LYE), LTD. on the BROCKHOUSE stand (D405/304); GEORGE H. ALEXANDER MACHINERY, LTD. (D632); and JOHN GARRINGTON & SONS, LTD. (Outdoor 1325/1224).

Mechanical Testing Equipment

The testing machines exhibited by SAML. DENISON & SON, LTD., on Stand D247 will include a 50 ton Model T42B Dial Indicating Universal Testing Machine, a 150 ton Compression Testing Machine, a 5·5 ton Model T42 Dial Indicating Tensile Testing Machine, and a 15,000 lb. Model T42U Dial Indicating Universal Testing Machine. The Model T42 is, perhaps, of special interest: made in five capacities, 1,250 lb., 2,500 lb., 5,000 lb., 12,500 lb., and 15,000 lb., each machine has three sub-capacities and is thus virtually four in one. The standard equipment includes a single speed electric motor and two-speed gear box, but for accurate work, an auxiliary hand-operated gear box can be incorporated.

Along with a number of weighing scales, W. & T. AVERY, LTD., will have on show, on Stand D523/420, a range of testing machines. Of these a new development, an Electro-dynamic Balancing Machine (No. 7207) will be of considerable interest. The capacity range of this machine is from 2 lb. to 200 lb.

Hardness testing machines to be seen on Stand D632, (GEORGE H. ALEXANDER MACHINERY, LTD.) will include a portable Brinell tester and a Rockwell hardness tester incorporating the latest designs for simple and convenient operation.

Electrical Equipment

A number of the large electrical engineering concerns are exhibiting, as usual, but, as many of their products are so large, recourse is made to photographs and models to give the visitor an idea of the range covered by their activities.

The exhibits of the ENGLISH ELECTRIC CO., LTD., on Stand C613/512 can be summarised under nine main headings. They are: steam turbines, hydro-electric plant, diesel engines, air-blast and air-break switch-gear, transformers, textile and fractional horse power motors, fusegear, meters and instruments, domestic appliances. Models, some working, will cover the first three sections, while photographs will show examples of switchgear. The remainder of the sections will feature actual products from the range manufactured by the Company.

Against a background of heavy electrical plant, augmented by diagrams, photographic displays, and a scale model of a hydro-electric station, a comprehensive selection of B.T.H. products will be shown on Stand C511/410. The exhibits will include power-station and industrial switchgear; electric motors from fractional horsepower sizes up to 50 h.p.; electronic control gear; communication equipment; industrial electric heaters; and Mazda lighting developments.

Models of a transformer group, a hydro-electric alternator, a steam turbine, and a colliery winder will be featured by the METROPOLITAN-VICKERS ELECTRICAL CO., LTD., on Stand C510 together with a demonstration of two arrangements of standard motor and control gear. In one of these, the normal A.C. supply is fed to the motor side of a 9 kW motor generator whose output is fed to a 10 h.p. Type AMX Steelworks Auxiliary Motor, designed for heavy duty in iron and steel works, which is connected to an artificial load. The stand will be illuminated by Metrovick lighting and a showcase will house samples of precision castings manufactured by the Company.

In view of the importance of the generation, transmission and distribution of electrical power at the present time, the GENERAL ELECTRIC CO., LTD., will devote the whole of Stand C503/402 to its manufacturing

Courtesy of Newton Victor, Ltd.

" Raymax " 250 industrial X-ray unit.

resources for the equipment concerned. The stand will be divided into two parts, one devoted to turbo-alternators and coal-handling plant, and the other to certain designs of indoor switchgear selected from the wide range produced by the company.

Two of the main products of FERRANTI, LTD., transformers and power consumption meters, will feature prominently on Stand C615/514. Other exhibits will include a range of Ferranti instruments, a servomechanism of great sensitivity, domestic appliances, the Ferranti Neostron Stoboscopic lamp and cathode ray tubes.

Shown for the first time, on Stand C609, will be the CROMPTON-PARKINSON " Magnicon " Alternator which is self-regulating and will give satisfactory operation without a voltage regulator. Other electrical machines on this stand will include a sectioned fractional horse-power motor, and a range of ceiling fans. Metal clad switchgear, oil circuit breakers, on-load tap-changing gear, and a range of instruments will also be featured.

Oil

On Stand D421, the exhibit will be centred on the FLETCHER-MILLER range of cutting and grinding fluids, both straight and soluble. Grinding has received special attention by the recent introduction of three graded oils for fine grinding, production thread grinding, and centreless work individual in character. Other products displayed will include machine tool lubricants ; industrial lubricants for most works plant ; alkaline degreasing compounds and cold water cleaners ; rust and scale removers ; corrosion preventives, including de-watering fluids ; drawing compounds for light and heavy presswork ; a unique easing oil ; case-hardening compounds ; and quenching and tempering oils.

The wide variety of uses of petroleum products in almost every sphere, and the high degree to which industry and transport depend on oil will be illustrated most effectively on the SHELL-MEX and B.P. stand (D317/214). The 16 large panels can show only a few of the numerous ways in which petroleum products enter into the necessities and luxuries of our daily life, but two aspects of importance in the metallurgical field, fuel oil and lubrication, will be featured on the stand.

THE ESSO PETROLEUM CO., LTD., formerly the Anglo-American Oil Co., Ltd., have arranged an attractive layout for Stand D330. On either side there will be transparent pictorial illustrations of various industries together with pictures of the new Esso Fawley Refinery, at Fawley, Southampton, a £37½ million project put up by private enterprise which will be the largest refinery in Europe when completed. There will also be samples of petroleum products such as oils, greases, etc., on view.

The VACUUM OIL COMPANY stand (D349) has been so designed that the staff of industrial engineers and salesmen in attendance can, by means of coloured transparencies of sectioned pictures of engines and machines, explain to visitors the work lubricants have to do and the service the company can give in works.

In addition to industrial lubricants, cutting oils and insulating media, GULF OIL (GREAT BRITAIN), LTD., on Stand D532, will have on show several grades of lubricants specially developed for the fabrication and cold-working of both ferrous and non-ferrous metals. Special mention should be made of Fine Wire Drawing Oil AL which has been used successfully for drawing aluminium, copper, nickel and their alloys into wire as fine as 0·0006 in., and stainless steel to 0·002 in., excellent surface finish and increased die life resulting from its use.

Miscellaneous

On Stand D402, DELORO STELLITE, LTD., will show a range of exhibits showing how Stellite hardfacing is being used to combat wear, heat and corrosion, and demonstrations of the deposition of Stellite by the oxy-acetylene process will be given. Precision castings in Stellite will also be featured, together with a comprehensive display of standard and special tools.

The chief exhibit on the NEWTON-VICTOR stand, C709, will be a Raymax 250 unit, a complete mobile industrial X-ray unit suitable for the examination of castings and welded joints and other fabrications up to a thickness corresponding to 3 in. of steel. Mounted on a robust chassis equipped with large pneumatic-tyred wheels, the unit can be used in any location where power is available.

For the first time for many years, BIRLEC, LTD., are not showing any furnace equipment on Stand D509. Instead emphasis will be on the Birlec-Lectrodryer equipment for the controlled dehydration of gases, including air, and certain organic liquids. By using two beds of activated alumina, one absorbing and the other being reactivated by heating, continuous drying can be achieved.

A selection of " Autolec " steam raisers and hot water boilers will be displayed by G.W.B. ELECTRIC FURNACES, LTD., on Stand C321, including 30 kW and 70 kW steam raisers and 100 kW and 350 kW automatic hot water boilers. The " Autolec " electrode boilers represent a new approach to steam raising as they are self-contained, fully automatic units which can be placed in virtually any position.

Interesting links with the past will be found on the KELVIN & HUGHES stand (D626) where numerous scientific instruments owing their origin to Lord Kelvin will be displayed. Three panels will show present-day instruments which will include a loss-meter, a three-line recorder, flue gas analysis equipment, a temperature

Continued on page 196

High-Temperature Steels and Alloys for Gas Turbines *Continued from page* 168

combined-stress machines to accommodate furnaces and to provide static bending and tension in addition to reverse bending. Tests on three rolled and two cast materials at temperatures in the range 500°–800° C. had shown the S/log N curves to be, in general, straight. Under reverse bending, a typical result showed a decrease of some 50% at 800° C. as compared with 20° C. The effect of static tension superimposed on reverse bending, for instance, on Nimonic 80, caused a general decrease of some 25% at 700° C., while at 800° C. the failure appeared to be largely by creep. Static bending, as opposed to static tension, superimposed on reverse bending produced only a slight decrease. A few tests on actual blades suggested that machining from bar was probably preferable to forging close to size and honing.

GRESHAM and HALL described their now well-known equipment, of the rotating cantilever type, and quoted a few examples of tests which were mainly devoted to the effect of different forms of attack. They also referred to a new type of electronic machine which was under development. In addition to the variables affecting fatigue resistance at normal temperatures, there were the added variables of temperature and the speed effect, which meant that much more work was necessary to explore a material thoroughly.

TAPSELL's paper was largely devoted to indicating methods of using a comparatively limited amount of information, and indicating what the particular type of information needed was, and how it could best be made use of in design. With high mean stresses, failure was usually dependent on creep, whilst with comparatively high alternating stresses and low mean stresses, fatigue was the important factor; means were suggested for estimating what happened between the two extremes.

Discussion

MR. E. R. GADD (Bristol Aeroplane Co., Ltd.), in opening the discussion, said he would confine his remarks to the papers on fatigue. In the early stages of turbine engine development, considerable attention had been given to the creep properties of the materials, but insufficient attention had been paid to hot fatigue. Using cast Nimonic 80 blades in a development engine, fatigue failure had occurred, the trouble being eliminated by the use of wrought material. Subsequent tests had shown that the cast version of Nimonic 80 was inferior in fatigue properties to the wrought alloy, but that as the temperature of testing was raised and the cycles to endurance increased, the difference tended to disappear. A similar tendency had been suggested by rather limited tests on G18B. Specially developed alloys having good creep and fatigue properties in the cast condition had now been produced, although they contained rather large amounts of strategic elements. Cast rotating blades were not attractive to the designer in view of inspection difficulties, but they had advantages from the production angle. Reference had been made by Frith and by Tapsell to the combined effect of creep and fatigue, and he thought it likely that for a given material, it would be possible to determine a temperature above which creep predominated and below which fatigue was more important.

MR. C. T. EVANS (Elliott Co. Inc., U.S.A.) said that the behaviour of materials at elevated temperatures in atmospheres other than air presented what was probably the most serious problem confronting the development of land and marine gas turbines. Some interesting contributions had been made to a Symposium on the Corrosion of Materials at Elevated Temperatures which was held during the Annual A.S.T.M. Meeting in 1950. A series of tests on Hastalloy "C" at 870° C. showed that air was the most favourable testing medium, with strength decreasing in the following order: vacuum; nitrogen; hydrogen; helium; helium 67%, hydrogen 33%; and helium contaminated by disintegration of a silicone gasket, giving about 1 mol.% nitrogen and 0·17 mol.% carbon monoxide. Their own laboratory had contributed work on oil-ash and coal-ash corrosion, mainly the former, although certain foreign coals appeared to contain appreciable amounts of vanadium. He did not share the optimism that corrosion difficulties would not be encountered in burning residual fuels if the metal operating temperatures could be kept below about 650° C., as many eutectics which might be present had melting points below 580° C. Working with natural ashes, tests had shown some to attack certain alloys at 540° C. Most investigators referred to V_2O_5 corrosion but they had been unable, by X-ray diffraction, to identify V_2O_5 as being present, and had concluded that complex vanadates were the trouble makers. Sykes and Shirley confirmed their own findings that no intergranular attack occurred up to 800° C. except in the high nickel alloys, doubtless due to the sulphur and sodium compounds present in the ash. On the other hand, they did not agree with Sykes and Shirley that vanadium did not volatilise readily at temperatures of 750° C. This factor emphasised that ashing heavy oils at red heat could lead to very misleading results. For oil or ash treatment, a favourite candidate was some form of calcium additive which showed promise, in spite of the fact that it would lead to increased ash, and that the salts formed, such as calcium sulphate, were insoluble, which complicated the removal of the deposits. An encouraging feature of the problem was that test experience with turbines was not so bad as laboratory tests would predict.

MR. H. J. J. REDWOOD (Admiralty) pointed out that for gas turbines to supersede other types of prime mover for naval use, they would have to show advantages in efficiency and/or weight and space, as well as being able to burn heavy fuel oil. The high temperatures called for by efficiency requirements would accentuate the V_2O_5 corrosion problem which must be considered of major importance. As Mr. Evans had pointed out, engine tests seemed more hopeful than laboratory tests had indicated and it was hoped to carry out long-term endurance tests on heavy oil. He suggested that the possibility of finding a material or coating resistant to attack should be explored along with blade cooling methods.

DR. W. SIEGFRIED (Sulzer Bros., Switzerland) referred to their own extensive studies of two difficulties associated with vanadium, namely, fouling of turbine blades and excessive oxidation of air-heaters due to operating at 700°–800° C. They concluded that fouling was essentially determined by the vanadium content and further tests were being carried out to determine the effect of other constituents of the ash. Annealing tests on plates on which ash was placed gave different results from those on tubes inserted in a stream of hot gases from an oil burner, when coatings of chalk, etc., were applied. Little effect of the coating was found on plate

tests, but improvement was effected in the tube tests, due, presumably, to the reduction of adhesion by the chalk. Other protective coatings were tried but, in general, the effectiveness of the coatings diminished with time. Further tests showed that, for corrosion and deposit formation, the alkali content of the oil played an important part, and that direct contact with combustion gases caused much heavier attack than occurred when a plate covered with ash was heated in air.

User Aspects

Research and Future Needs

The papers presented in these two sections were :

Materials and Performance. By A. T. Bowdon and W. Hryniszak.
Gas Turbine Performance and Materials. By J. Bucher.
Influence of Operating Temperature on the Design and Performance of Gas Turbines. By S. L. Bragg.
Stresses in Gas-Turbine Discs and Rotors. By R. W. Bailey.
Research and Development on High Temperature Materials. By C. A. Bristow and H. Sutton.
Future Needs in Materials for Land and Marine Gas Turbines. By J. M. Robertson.

The rapporteur, MR. R. G. VOYSEY (Ministry of Fuel and Power), said that if he were asked to summarise the papers on User Aspects in one sentence, he would say that the engineers were still asking for higher temperature materials. BOWDEN and HRYNISZAK pointed out that the high cost of materials, and the difficulty of preparation in large rotor sizes and very special blade shapes, caused some concern in the commercial development of the gas turbine. More information was needed on long-term life, in particular, an assurance that creep curves carried an adequate factor of safety against variation of specimen and the difference between long-term and short-term behaviour. No trouble was expected from ash in normal fuels provided that temperatures were kept below 650° C., but an ash-free environment was essential at higher temperatures. No special material problems were set by compressors, but careful design was necessary in combustion chambers and ducting, whilst heat exchangers emphasised the need for cheap materials capable of withstanding the temperature and corrosion conditions. The large number of stages needed with reaction blading, which was essential for high efficiency, further emphasised the importance of cheaply produced materials.

In the second paper, BUCHER compared the open- and closed-cycle turbines from the material aspect, and pointed out that the closed-cycle designer was more interested in materials which would withstand stresses of 1–2 tons/sq. in. for 100,000 hours at 700° C. than in materials which could be used at 5–6 tons/sq. in. at 650° C. The dangers of using extrapolated life curves and the importance of a few check points at 20,000 and 50,000 hours were emphasised. For air heaters, the effect of considerable cold work and of welding on the high temperature properties needed exploration. Whilst the requirements of the high temperature parts of the design were most stringent, there was scope for a material intermediate in quality between the present kinds of ferritic and austenitic steels. As turbine blading could be more easily replaced than air heater tubing, a suitable material for both would be one with a life of 10,000–20,000 hours at 5 tons/sq. in., and 100,000 hours at 1·5 tons/sq in., both at 600° C.

The paper by BRAGG included a detailed analysis of the factors affecting gas-turbine design, and made out a strong case for higher temperatures. An interesting table summarised fairly completely the work which had gone into the paper itself.

Whilst the rarity of a major failure of a disc or rotor was encouraging, BAILEY considered that there was little ground for complacency about the criteria for comparing calculated stresses with material properties. Consideration of the stress in a typical thick disc, with full allowance for thick-disc effects and for yielding, emphasised the importance of the plastic properties of materials, and, in turn, the importance of such processes as warm-working. Whilst simple theory suggested that a bored disc was inferior to a solid disc of similar size, plastic strain could relieve stress concentrations and it might even be preferable to remove the centre of the disc if its properties were doubtful. Comparing ferritic and austenitic steels, Bailey said that the good plastic properties of the ferritic steels led to the ultimate tensile strength being an adequate criterion, but the possible presence in austenitic steels of brittle networks might lead to the full plasticity not being available and a figure of about 80% of the tensile strength was suggested for use in design. The plastic properties were most important in the centre region of the disc, and a method of making an hydraulic test on a cylinder cut from the bore was described. Discussing thermal stresses, a bend test specimen was described which indicated the sort of tensile strains allowable for limited numbers of cycles of reversal.

In the paper by BRISTOW and SUTTON, consideration was given to strategic materials, titanium being shown to be fairly abundant, whilst the importance of conservation of such elements as cobalt and niobium was emphasised. Concentration of the sought element in its natural environment was not considered quite so significant as had formerly been the case. The common base metals of high temperature materials were discussed, and Pederson's criterion for evaluating the rarity rating of an alloy was noted. The importance of research on other than " pure metal " alloys was mentioned and reference was made to the long-range research work going on at several centres.

ROBERTSON pointed out that the maximum usefulness and conservation of materials could only be gained by close collaboration, at all stages, between manufacturer, designer and builder. Factors involved in the use of metals in gas turbines were examined under the headings of mechanical properties, resistance to corrosion, high-temperature stability, and physical properties. The importance of availability of material was suggested as requiring growing emphasis, as was also the best use of scrap. It was pointed out that the properties of an alloy could be greatly affected by the making, shaping and treating factors ; welding and brazing called for more attention. Surface treatment was referred to as a possible means of enabling more easily available materials to be used. A survey was given of the materials at present available and of typical operating conditions for components.

Discussion

DR. H. ROXBEE-COX (Ministry of Fuel and Power), in opening the discussion, said that the application of a gas turbine should be considered as a strictly economic problem, to be assessed against the background against which it is going to work. He would like to see an analysis of the material costs, showing the relative

amounts for the various parts of the machine. In discussing the problem of vanadium attack, Bucher had suggested three possible remedies: (1) by additions to the fuel; (2) by change of composition of the material; and (3) by surface coatings. Another possibility was that of indulging in slightly inefficient combustion. On the question of disc stresses, Dr. Roxbee-Cox asked about the effect of disc cooling on thermal stresses, and about the possibility of using laminated discs. In conclusion, Dr. Roxbee-Cox said he would like to ask Dr. Robertson whether he agreed with Mr. Bucher's suggestion that there was scope for steels intermediate in price and properties between the present austenitic and ferritic materials.

The Chairman (Mr. D. A. Oliver) said he wanted to "high spot" a few considerations which might be considered in the subsequent general discussion. Dealing first with aero turbines, some expression of opinion as to whether all the effort should go into the improved ferritic discs would be helpful, whilst on the industrial type some up-to-date views on the pros and cons of ferritic and austenitic materials, and on bolted versus welded construction would be welcome. Quick returns would come from increased effort on sweat-cooling—to what extent could it be made use of in design? Other fruitful topics for discussion included closed- and open-cycle designs, drum or disc-type rotors and, perhaps most important of all from the metallurgical point of view, the effect of the shortage of essential ferro-alloys.

Referring to the problems of the closed-cycle turbine, Dr. C. Keller (Escher-Wyss, Ltd., Switzerland), said they were nearer to those of the steam turbine than to those of the gas turbine. They had some advantages compared with the open cycle, because they had two definitely separated cycles. In the working cycle, with pure air under pressure, they had only stress problems and no chemical problems, and the stresses were much lower. On the other hand, they had the air heater, corresponding with the boiler in steam plant, where chemical attack did occur. As a guest, he said he would like to express the indebtedness of the Swiss gas turbine makers generally to British metallurgists for the co-operation they had received. There seemed to be different ways of looking at design problems. In steam turbine practice, they used to ask for high impact figures for welds and so on, but when they asked for quotations for rotors and welding material, nobody in Britain was willing to give any guarantee on impact figures. Was it that British designers did not attach much importance to impact figures? A number of tests had been carried out on tube specimens heated to working temperatures, with compressed air under actual working pressure inside, to see what happened. Bursts had occurred when higher pressures had been used, but they never occurred sharply; it was always possible to see when the tube was going to crack by the considerable bulging which took place. They felt, therefore, there was no danger of a sudden explosion.

Mr. H. Capper (Admiralty) said he would like to endorse the view, expressed in Robertson's paper, that any information on the distribution of stress in the various components was extremely valuable. In order to satisfy the desire of the metallurgist to know the future needs in the way of materials, the Engineer-in-Chief's department of the Admiralty had made a bold attempt to state those requirements for naval gas turbines. Apart from the small units, naval turbines, even in wartime, only operated at full power for a small proportion of their running time, and as it would be uneconomical to design a turbine to operate at full power all its life, an attempt had been made to assess the overall effect. Unfortunately, he was unable to give the actual figures obtained, but he felt that the knowledge that the attempt had been made might provide a spur to designers in other fields to make a similar estimate.

Dr. R. W. Bailey (Metropolitan-Vickers Electrical Co., Ltd.), in reply to Dr. Roxbee-Cox, said the effect of thermal stresses was more important with rotors than with discs as there were also the axial stresses to be considered in the former. With regard to laminated discs, there would be a certain amount of inequality in the stressing of such discs and it would be a matter of experience to see how they worked out in practice. Dr. Bailey then proceeded to discuss the question of long-term operation and the effect of what was really a very long heat treatment during service. Not only might the material creep in service, but its resistance to creep might change, and the effect of thermal change in the material was a most important factor in design. If it were necessary to use an accelerating factor in creep testing, that factor should be increased temperature and not increased stress, if a safe answer were to be obtained. Even that by itself was insufficient and it was necessary to make creep tests after periods of heating. As a result of experimental work he felt that the field of the complex austenitic steels was the short-life turbine, whilst for a life of 100,000 hours they might be no better than the much cheaper ferritic material. The material supplier had, of course, to sort out a whole range of alloys and his approach and testing technique would undoubtedly differ from those of the engine builder, but there was no doubt that the latter should follow out a testing procedure in which allowance was made for the thermal action on the material

Dr. N. P. Allen (National Physical Laboratory) suggested that the engineer should adapt his ideas to the properties of the materials and if, as had been pointed out, the austenitic alloys had a tendency to lose their properties after a long time, there was something to be said for replacing them before that stage was reached, thus making use of the full properties. Regarding corrosion, he said that the trouble due to vanadium pentoxide would be minimised by careful attention to cleaning of the turbine so that the corrosion products did not accumulate. If it were ensured that the amount of slag and ash on the blading was small in relation to the amount of metal there, the risk of loss of strength was very much less. At the beginning of another phase of intensive development work, Dr. Allen put in a plea that systematic work should not be crowded out, otherwise progress would not be maintained. One of the most important fundamental problems facing those developing high temperature materials was that of the brittleness of chromium. Work in progress at the N.P.L. on iron had shown that the transition temperature in that metal could be changed considerably by very small additions of various elements and similar considerations might apply in the case of chromium.

For gas turbines to be competitive Mr. W. Huber (Sulzer Bros., Switzerland), said that considerable savings throughout the whole life were necessary to offset the high initial cost. A close study of the question

showed that the effort to reduce prices must begin with construction, but must also cover manufacture and materials. Blading formed a high proportion of the total cost, and by machining from bar some 87% was machined away, involving waste of material and time. New methods of producing blades would have to be adopted, stamping and precision casting being two possibilities. Another problem which would have to be overcome, if the gas turbine were to be an economic proposition for land and marine use, was that of burning heavy oils.

A further plea for more information on long-term properties was made by Dr. J. S. Blair (Stewarts & Lloyds, Ltd.), who said it was begging the question to extrapolate on double log. papers, assuming that the law governing creep was known, and that it was a very simple logarithmic law. Long-term testing was necessary, and if any accelerating factor were needed, he agreed with Dr. Bailey that it should be temperature. As an engineer, he agreed with Dr. Allen that designs should be adapted to materials, but he was appalled at the thought of the effect on power cuts of replacing power plant parts almost annually.

Mr. S. T. Harrison (Armstrong-Siddeley Motors, Ltd.) said that he understood from Bailey's paper on disc stresses, that on cooling down after running, the rim was left in tension which would, he thought, make the disc size smaller (as in the case of a hoop round a barrel) but his own experience showed that they invariably grew. Discs could grow if certain stresses exceeded the elastic limit, but in the case of discs which had grown considerably, the stress analysis did not appear to explain the origin of stresses of sufficient magnitude to account for the observed growth. Mr. Harrison showed a slide of an overspeeded disc which had burst from the hub in a brittle manner; there was no evidence that any relaxation had occurred. Tensile tests taken on the fragments gave no indication of brittleness or weakness. Turning to the question of sulphur attack under conditions of incomplete combustion, Mr. Harrison pointed out that such conditions were likely to arise in combustion chambers, particularly those having vaporiser chambers. They had run into serious trouble using nickel-base alloys, failure occurring very quickly under conditions where ash was deposited under very strongly reducing conditions and where the temperature was above the melting point of the nickel/nickel-sulphide eutectic. This trouble had been experienced with oils with high ash contents, the ash being mainly calcium sulphate.

Mr. G. T. Harris (Wm. Jessop & Sons, Ltd.), commenting on Bailey's statement concerning the unreliability of austenitic discs compared with ferritic ones, said that, in tens of thousands of G18B discs, less than five had failed, all on the test bed and some under rather suspicious circumstances. There was no doubt that a very high standard of inspection was necessary to ensure that no failures occurred. They had had a fair amount of success in correlating the results of ultrasonic and gamma-ray non-destructive testing with tensile tests taken across the centre of the disc.

Dr. N. Stephenson (National Gas Turbine Establishment), referring to their own experiments on vanadium-pentoxide attack, said that they had shown that the mechanism might be complex and might vary between alloys. Above 700° C., and in the presence of vanadium-pentoxide, they found that the nickel-20% chromium and cobalt-20% chromium alloys were superior to the iron-base heat-resisting alloys. Extensive laboratory tests had failed to discover an alloy or coating which did not suffer at least some accelerated oxidation under those conditions. Referring to Dr. Roxbee-Cox's suggestion that inefficient combustion might prevent attack, Dr. Stephenson said they had found that in such circumstances, vanadium pentoxide tended to be taken up by the carbon particles resulting from incomplete combustion, and there was some reduction in the amount of ash deposited. The use of inhibitors was affected by the presence of sulphur in the fuel, as in certain circumstance the vanadates were partly sulphated with the liberation of vanadium pentoxide and consequent reversion to accelerated oxidation.

Dr. E. R. Robinson (General Electric Co., U.S.A.) said that what had struck him most was the emphasis placed on creep strength, whereas in the States they had begun to think more in terms of long-term rupture strength. One other matter which seemed most important was the shortage of strategic materials; it was essential that serious consideration should be given to the most effective use of the available resources.

Pointing out the need for a target at which metallurgists could aim, Mr. H. W. G. Hignett (Mond Nickel Co., Ltd.) said that only three pointers had been provided in the papers and discussion. First, there were Dr. Bailey's intriguing comments, to which metallurgical research might rightly devote a good deal of attention; secondly, there were Mr. Bragg's constructive conclusions to his paper, that emphasis in development should be on blade materials with the same stress at higher temperatures, rather than on higher stresses at the same temperatures; and thirdly, Mr. Bucher's request for a new material for service at 550°–600° C. Concerning long-term testing, Mr. Hignett felt that present day designers would have little interest in materials put under test 11½ years ago.

Dr. R. Graham (Shell Refining and Marketing Co.) commenting on the obnoxious properties of vanadium pentoxide, said that Dr. Allen had given the answer in a nutshell when he said that it was all a question of quantity. Whilst there was a correlation between laboratory and combustion tests, it was qualitative rather than quantitative. They had carried out a good deal of experimental work on doping the fuel as a preventative but the position did not appear to be very hopeful.

As far as costs were concerned, Dr. A. T. Bowden (C. A. Parsons & Co., Ltd.) said that blading accounted for 12–15% of the total, and spindles a like proportion in large industrial units. The difficulty and cost of obtaining large austenitic forgings put considerable pressure on the industrial manufacturers to use ferritic steels. Although there were differences in time and material used, there was little difference in final cost between the various ways of making blades. In regard to deposition from the products of combustion, Dr. Bowden said that by chilling the products of combustion to a small degree, or by coarsening the spray, one could get comparative freedom from deposition through coating the residual ash with a fine deposit of carbon. There were limits to the extent to which that could be carried out, as too large a particle size resulted in erosion. It was probable that distillation would, in the end, be far cheaper than making additions to the oil.

Mr. J. B. Bucher (John Brown & Co., Ltd.) said that

an earlier statement that ten 10,000-hour creep tests were worth more than ten times as much as one 100,000-hour test did not agree with a number of other contributions to the discussion. Even if the materials used to-day were not in use in 11 years' time, it would be advantageous to know how austenitic steels behave after 100,000 hours' service. Both Dr. Roxbee-Cox and Dr. Bowden had suggested that inefficient combustion might result in carbon blanketing and thus inhibit vanadium attack, but extensive tests had shown no appreciable improvement. Additions to the oil could result in reduced attack, but the best additive they had found was too expensive to use. He was surprised that Dr. Graham had found no attack on Nimonic 80; in their experience attack did occur, although less so than with other materials.

Vote of Thanks

The Chairman, MR. D. A. OLIVER, expressed sincere thanks to the authors for their contributions and for their magnificent efforts over a very long period; to the rapporteurs for their excellent presentation of groups of papers which were often of a very diverse character; to the Council of the Institution of Civil Engineers for the use of their Great Hall; and to the staff of the Institution for the special efforts they had made for the comfort and convenience of those taking part in the Symposium.

DR. C. SYKES, on behalf of the members, expressed appreciation to MR. OLIVER for his efforts in organising the Symposium and for presiding at its sessions.

MR. OLIVER briefly responded and the proceedings terminated.

World Metallurgical Congress

E.C.A Sponsored Mission

IT has been decided by E.C.A. that it will sponsor, provided sufficient support is forthcoming, a mission to the World Metallurgical Congress of experts from O.E.E.C. countries. The Congress will provide an ideal opportunity for information to be exchanged on such subjects as steel making and refining, preparation of metals, research in metals, marketing, fabrication of metals, machining, welding, etc. The mission will, in addition, have the opportunity of visiting factories and research institutions in the U.S.A. Eight separate tours of about 20 visits each are being arranged so that the experts can study the subjects with which they are most closely connected.

Dr. Zay Jeffries is the Director of the Congress, which is sponsored by the American Society for Metals, 7301, Euclid Avenue, Cleveland 3, Ohio, U.S.A., and which will coincide with the National Metal Congress and Exposition at Detroit. When he recently visited London, the British Engineers' Association had an opportunity of participating in discussions concerning the Congress with the hope that U.K. representatives would be included in the O.E.E.C. mission, which it is anticipated will arrive in the U.S.A. by September 10th, 1951.

Many engineers and others from the U.K. will doubtless be taking part in the Congress on their own account, and making their own arrangements direct with the American Society for Metals. Those wishing to be nominated as members of the O.E.E.C. mission may obtain information from the British Engineers' Association, 32, Victoria Street, London, S.W.1.

Ironfoundry Advisory Team

THE team set up by the British Cast Iron Research Association with the support of the Joint Iron Council has now been completed and will visit iron foundries in the United Kingdom to study and report on their operating efficiency. The leader of the team is Mr. J. Hunter, who has had considerable experience in the design and equipment of foundries, and who has been for the last six years manager and chief designer of the foundry equipment division of Stone-Wallwork, Ltd. Mr. A. A. Timmins was trained in the laboratories of the Association and has since had responsible managerial experience in the industry. Mr. J. A. Ballard took the Diploma of the National Foundry College in 1948 and then spent two years in a number of foundries as a holder of a Fellowship of the Worshipful Company of Founders. The reports of the team will be confidential to the member-firm, and any British foundry may become a member of the Association by signing an application form, which will be furnished on request.

An engineer, Mr. W. D. Bamford, A.M.I.E.E., has also been appointed to advise foundries anxious to meet the requirements of the Garrett Report on heating and ventilation problems.

Spanish Institute of Iron and Steel

SOMETIME during October of this year, the Spanish Iron and Steel Institute is planning to hold its 11th General Assembly in Madrid. The assembly will last about a week and will be preceded by several collective visits to important industrial centres in other parts of Spain. In Madrid, technical sessions will be held, together with social events and visits to places of interest which will enable visitors from abroad to appreciate the beauties and customs of Spain. Further details concerning dates, etc., may be obtained from Director of the Instituto del Hierro y del Acero, Villanueva, 15, Madrid, Spain.

Engineering, Marine and Welding Exhibition

ENGINEER Vice-Admiral Sir Harold Brown, G.B.E., K.C.B., has accepted the position of Honorary President of the Engineering, Marine and Welding Exhibition which will be held at Olympia, London, from August 30th to September 13th, 1951.

Sir Harold was Engineer-in-Chief of the Fleet, Admiralty, from 1932 to 1936. He occupied the position of Honorary President of the Engineering and Marine Exhibition in 1937, at which time he was Director-General of Munitions Production, Army Council, War Office. During the last war, Sir Harold held the posts of Director-General of Munitions Production (Ministry of Supply), 1939-41; Controller-General of Munitions Production, 1941-42; Senior Supply Officer, Ministry of Supply, 1942-46.

The Engineering, Marine and Welding Exhibition includes, this year, the Foundry Trades Exhibition. The Exhibition has been held biennially since 1906, except for the interruptions caused by the two world wars. It claims to be the largest exhibition in the world solely devoted to the display of engineering manufactures.

Cold Working of Non-Ferrous Metals

Metallurgical Aspects Discussed at Symposium

At the Annual General Meeting of the Institute of Metals, held recently in London, a day was devoted to the presentation and discussion of a series of papers constituting a symposium on cold working. Five papers were presented by authorities on different aspects of the subject and considerable discussion resulted on which these notes must be regarded only as a brief summary.

THE 1951 Annual General Meeting of the Institute of Metals, held in London on March 13th–15th, will be especially remembered for an outstanding Symposium on the Metallurgical Aspects of the Cold Working of Non-Ferrous Metals and Alloys, which brought together metallurgists, plant designers, and practical operators in cold rolling. The symposium consisted of five papers dealing with fundamental aspects, lubricants, cold rolling in sheet and strip form, wire-drawing technique and deep drawing and pressing. Although only a day was given to the presentation and discussion of these papers, a considerable number of members were able to contribute and the two sessions which it comprised proved to be lively and informative. Although a number of other important papers were presented at this meeting, owing to limitations of space, it is considered advisable to confine this brief summary to the symposium.

The papers presented included " Fundamental Aspects of the Cold Working of Metals," by Maurice Cook and T. Ll. Richards ; " Lubricants for the Cold Working of Non-Ferrous Metals," by S. F. Chisholm ; " The Cold Rolling of Non-Ferrous Metals in Sheet and Strip," by C. E. Davies ; " Wire-Drawing Technique and Equipment," by F. T. Cleaver and H. J. Miller ; and " The Deep Drawing and Pressing of Non-Ferrous Metals and Alloys," by J. Dudley Jevons. The President, Professor A. J. Murphy, occupied the Chair.

Fundamentals Aspects of Cold Working

Professor F. C. Thompson, who introduced the papers, referred to that by Drs. Cook and Richards as providing a background study of the fundamentals of plastic deformation, so far as can be done in the light of existing knowledge. For a proper appreciation of metallic properties, the authors refer to the electron theory of metals, according to which the valency electrons of the metal in the solid state, or at least a definite proportion of them, are not associated with particular atoms. A metallic crystal is thus considered to be an assembly of positively charged ions in a cloud of free electrons, the positive ions being held together in positions of minimum energy by the opposing forces of electrostatic attraction between their positive charges and the negative charges of the electrons, and repulsion between their own positive charges.

The authors briefly outline several mechanisms involved in plastic deformation, including crystallographic slip, twinning, and kinking, and a shear mechanism to which particular attention is drawn because of its importance in many metal-fabrication processes. The influence of plastic deformation on structure is described with special reference to the development of preferred orientation in view of its technological significance, while the diffraction studies are considered in terms of the dislocation theory. The relation of work hardening and plasticity to the structural changes brought about by cold working is also discussed.

Lubricants for Cold Working

The remaining papers covered more practical aspects and, in introducing Mr. Chisholm's paper on lubricants in the cold working of non-ferrous metals, Professor Thompson emphasised the important part they play; indeed, he pointed out, the lubricant selected for any cold working operation may be the factor that determines, more than any other, whether the operation is a success, a view which is supported by the fact that this question is discussed in each of the remaining papers. Mr. Chisholm discusses, in turn, lubrication in cold-rolling, press-work, and tube and wire drawing. In connection with cold-rolling, he makes the interesting point that if the fact that slip occurs between the strip and the roll be accepted—and few would be disposed to doubt it—it would, under certain conditions, be possible to improve the lubricating properties of the roll lubricant, and thereby reduce the friction between the metal and the roll to such an extent that it would be impossible to roll at all.

The selection of the appropriate roll lubricant does not, therefore, aim at the elimination of friction, but at keeping it under proper control. Incidentally, it is noted that extreme pressure ingredients are not suitable for such application on account of their surface activity.

Broadly speaking, the higher the viscosity of the oil the greater will be the reductions obtained per unit roll load. On the other hand, high viscosity oils do not produce such good surface finish and may contribute to dirty annealing. Low viscosity oils normally give a good surface finish and cleaner annealing, though the reductions per unit roll load are not so great. In order to get the maximum benefit from both types, the aim is to combine load-carrying and lubricating characteristics by suitable additions. In the breaking-down process, where surface finish is not normally so important, a fairly heavy oil may be employed. The importance of the sulphur content of the oil is stressed in connection with the staining of the strip during annealing, it being generally believed that with a sulphur content below 0·5% such staining troubles should not be encountered.

In addition to the discussion of many aspects of the processes of cold rolling, press drawing, tube drawing, and wire drawing, from the point of view of the demands they make on lubricants. Mr. Chisholm suggests suitable types of lubricant in each case.

Cold Rolling Non-Ferrous Metals

After reviewing recent progress in rolling practice, Mr. Davies describes modern technique in rolling non-ferrous sheet and strip. The scope of his paper is limited to large-scale output from non-ferrous mills, namely, copper and aluminium and their alloys. Although these materials have many features in common, the plant employed and the technique practised differ considerably. The practice of cold-rolling light metals has been largely based on that developed for the rolling of mild steel, as Professor Thompson stated in his introduction of the paper, where the trend has been towards an ever-increasing weight of ingot and, consequently towards heavier coils. Increased output has been achieved by the use of heavier ingots, which makes economical the use of higher rolling speeds and heavier reductions per pass, in conjunction with the development of the four-high or backed-up roll mill, first as single units, reversing or non-reversing, and later in multi-stand tandem trains.

One of the most important contributions to the progress of rolling mill design has been the development of more efficient bearings. Until the problem of the heavy frictional losses in these bearings was solved, by the production of roller bearings capable of carrying the heavy loads, and the later development of the fluid-film oil-lubricated bearing, little or no advance in rolling speeds was possible. Mr. Davies states that before these vital improvements in the mechanical efficiency of the rolling mill, the frictional losses in the roll-neck bearings were quite normally as high as 50% of the total power consumption of the mill, and in some cases as high as 90%.

Dealing with the breaking down of ingots, Mr. Davies states that in this country, in the larger mills, a large range of brass alloys is increasingly broken down hot. In America, by comparison, the ingot is broken down cold, even in the largest and most modern of plants, a difference of practice mainly due to the output of such mills having a large proportion of leaded brasses which cannot be successfully hot-rolled, or to the use of a relatively high proportion of impure scrap.

In Sections II and III of this paper, which are concerned, respectively, with the cold rolling of copper and its alloys, and aluminium and its alloys, a very valuable discussion is included on the design of plant and its auxiliary equipment, and a number of typically modern designs which incorporate features of special interest are discussed and illustrated.

Wire-Drawing Technique

After a short historical introduction, Messrs. Cleaver and Miller, in their paper on the technique of, and equipment for, wire-drawing, consider the evolution of modern methods and point out that the important increase of speed achieved in the twenties can be ascribed mainly to the introduction of the tungsten-carbide die, which revolutionised both the methods and the machines used for producing the coarser gauges of wire, while at the same time they improved both the quality and finish. Details, with illustrations, are given of carbide dies suitable for drawing copper, and, for comparison, for steel ; similar information is given for diamond dies. They emphasise that the use of a correct die contour is most important in determining that the wire shall be worked more or less uniformly throughout the section, and that at too high die angles the cold-working effects are not transmitted to the centre, which leads to internal fractures of the cup and cone type ; too small angles, on the other hand, result in excessive friction, high power consumption and the possibility of the wire breaking in pure tension. At the same time, they stress the importance of back-relief, so that the expansion of the drawn wire, when it leaves the die, can be accommodated. This, with very hard metals, such as tungsten, is very different from that used in dies for copper and similar soft materials.

The trend has been towards standardised reductions per draft of the order of 20 to 25%, rarely exceeding 30% in the case of any of the non-ferrous materials. Annealing has been eliminated wherever possible, and at the same time copper may be drawn through all stages from the rod onwards without interstage annealing. Discussing the speed of drawing, the authors mention that, with the use of extra large diameter take-off reels, speeds up to 12,000 ft./min. for medium fine drawing have been reached, but the more recent tendency has been in the direction of some reduction.

A section of the paper is devoted to a consideration of die materials, in which the stages in the production of a carbide die from the rough cored pellet are illustrated ; extension of the carbide die technique has enabled the production of square, hexagonal and rectangular dies, which are now influencing machine design for the production of section wire in the same way as the introduction of the carbide die itself affected the machines for ordinary round wire. The factors which are enumerated as contributing to die wear include unsuitable or insufficient lubricant, foreign matter rolled into the wire, poor pickling or insufficient washing, unsuitable speeds, temperature and reduction or die contour, and finally variations in the quality of the die material. The authors next consider, at some length, the drawing of copper wire and illustrate representative flow sheets of normal British and American practice. It is noteworthy that American users favour the cone type of machine for quite heavy sizes, whereas in Britain, tandem machines would be employed, using fewer dies and much heavier reductions per draft.

In discussing annealing of copper wire, the authors point out that for some purposes such annealing is required on account of the directional effects which exist in the annealed material obtained after heavy reduction. The modified industrial practice now current has tended to give annealed wire greater tensile strength and lower elongation than was formerly obtained when interstage annealing was used, and the same problem is also considered in connection with the drawing of cadium-copper and brass. The production of fully annealed wire direct from the machine has now been accomplished on a satisfactory basis by electrical resistance heating, and the complicated problems involved, for instance, in the electrical pick-up without burning, avoidance of oxidation, uniformity of annealing, etc., have been satisfactorily solved. Excellent illustrations show typical examples of a modern plant and its evolution during the last 50 years and the authors conclude with their views on the probable trends of future development.

Deep Drawing and Pressing

In the introduction to his paper on the deep drawing and pressing of non-ferrous metals and alloys, Dr.

Jevons points out that these processes offer what is often by far the least costly and, not infrequently, the only practical way of making on a quantity-production scale an enormous variety of thin-walled articles ranging in size from a tiny electrical connector less than ⅛ in. dia., through a scale illustrated by cartridge cases, electric-lamp caps, tableware, kitchen utensils, food containers, to—turning to steel—such large articles as motor-car bodies and, in the United States, even baths and burial caskets.

Although the variations in technique used in deep drawing and pressing are considerable, they are covered, at least in principle, by five basic types of operation which are illustrated in the paper. A large number of apparently dissimilar operations encountered in industry are to be explained by the common practice of combining two or more of these basic types, to suit particular requirements. The author discusses the advantages and disadvantages of crank or hydraulically actuated presses, and remarks on the significance that the continued insistence on the advantage of the hydraulic press by those having a scientific outlook is being confirmed by the practical man on the floor of the shop This is more clearly seen in shops where both types of press are installed, for there it is found that, once the inherent conservatism of setters and superintendents has been overcome, the more difficult draws will inevitably be allocated to the hydraulic presses.

When several operations are needed to shape an article, Dr. Jevons is surprised that more extensive use is not made of continuous multi-punch presses, in which work is automatically carried through, up to even 10 sets of tools, by mechanical slides or fingers. In some cases an article which may require an intermediate anneal, when formed on separate presses, can be made on a multi-punch press without this unwelcome operation, so upsetting to the continuous line flow which delights the heart of the modern production engineer.

The material from which the press tools may be made is considered at length, and in connection with the use of sintered carbide, it is pointed out that a combination of less obvious advantages often justifies its adoption where long life would not. The excellence of the surface of the product reducing subsequent polishing costs, the deeper draws, reducing the number of press operations, and much closer dimensional limits maintained over longer periods, are among the advantages offered. Carbon and high-speed steel tools are considered, and in connection with the latter it is emphasised that free carbides must be thoroughly dispersed by adequate hot-working. Where nitrided steels are employed, and the usual ones have inadequate core strength, nitrided high carbon, high chromium steel often offers an effective solution. In the author's opinion, it is unfortunate that the nitriding properties of this steel are not more widely appreciated, since it gives the best wear resistance of any tool material yet available, with the exception of the much superior but very costly sintered carbide. Chromium plating, cast iron, zinc, rubber and even wood also receive attention.

Lubrication, which has been considered in connection with the rolling mill and wire drawing, received further attention, together with interstage annealing, critical grain growth, surface deformation, pickling, testing, etc. The paper in fact provides a most admirable summary of this interesting and important field.

Discussion

Mr. W. C. F. Hessenberg thought the symposium incomplete, a paper on the mathematical or macroscopic theories of plasticity and possibly another paper on the theory of friction might have been added, but acknowledged that it was so full of interesting material it would be ungracious to ask for more. He brought into the discussion a consideration of the work of deformation. In carrying out a tensile test on wire the strain was measured, during uniform elongation, by comparing the diameter of the wire before and after straining and calculating the work done in effecting that strain. In the case of wire-drawing, the same procedure was not permissible because the wire might have undergone more strain in going through the die than was indicated by its change in diameter, and also because work had to be done against friction between the wire and the die. He expressed the opinion that the theory of metal plasticity seemed to be getting more and more complicated without a comparable gain in unity.

On Mr. Davies' paper he referred to the mention of automatic control of strip gauge, a technique which the British Iron and Steel Research Association was actively investigating. His view was that automatic gauge control was perfectly possible, in principle, and the problem was essentially one of devising suitable servo-mechanical equipment to operate it. Watching the flying micrometer and making occasional adjustments to the rolls by power operated but manually controlled screws was too slow for modern rolling speeds. On the subject of gauge control he had not noticed any references to tolerances or thickness in the paper by Dr. Jevons, although operators had very definite views on the subject.

Mr. A. G. Hentz of Stockholm, referring to the paper by Drs. Cook and Richards, contributed some observations concerning crystallite or block formation in originally homogeneous crystals associated with the working of molybdenum in the incandescent lamp industry. The block structure, which he described and illustrated, seemed to be governed by the following four factors: (1) The degree of cold working of the molybdenum rod; (2) the temperature of working; (3) the size of the mother crystals; and (4) the orientation of the mother crystals.

Mr. Wistreich said that wire drawing was a process involving not only tension but also compression, and it seemed rather surprising that the texture of drawn wire should be different from the texture of rolled wire and of rolled sheet, that, in fact, it was the same as in wire pulled in a tensile test. He cited the work of other investigators on the subject and concluded that the texture was determined by the geometry of the deformation, but the actual technological process left its distinctive mark on the surface of the wire; a very important factor in the drawing of wire was the reduction per pass. He considered it confusing to speak of drawing and rolling textures; that at the centre of the material there were wire textures and sheet textures; that, when the actual technique used was considered, the most important place was the surface; and that textures had to be considered when the mechanical properties of the wire were studied.

Mr. E. C. Larke, referring to the paper by Mr. Davies, said that, during the development of a number of engineering aspects of the cold rolling of non-ferrous metals in sheet and strip form, there was the frequent

return to higher rolling speeds, heavier reductions, greater widths and heavier ingots, or, in brief, increase in production. The importance of this aspect could not be over-emphasised, and with this in mind he discussed the effect on output of delays which prevent metal from passing through the rolls and showed, by means of a specific example, the extent of the rise in output due to increasing the roll speed and the coil length, both individually and together. The example chosen related to strip material rolled from 0·030 in. to 0·013 in. in three passes at a speed of 300 ft./min., and the effect on output of increasing the speed to 600 ft./min. In addition, the rise in output as a result of doubling the length of the coil was also considered.

The example given showed that neither doubling the rolling speed nor doubling the coil length was very significant as regards increase of output; it was necessary to double both speed and coil length to get a significant increase. An important point brought out was the need to consider ways of reducing non-production time, since that factor alone was responsible for the fact that the actual output was only about 50% of the maximum possible output. Mr. Larke suggested that it would be a good plan for all concerns engaged in the rolling of metals to inaugurate a system whereby the causes responsible for the idle running of plant were systematically tabulated and analysed.

Mr. W. A. Fowler said that Mr. Davies referred, under the heading of gauge control, to the mill of the future, when it would be possible for the roll gap to be set under a pre-load in excess of the maximum required for any reduction. He understood that to mean the application of a load which would compensate for the housing stretch and thus eliminate that variable in its effect on gauge. The idea sounded attractive, but he recalled the efforts of operators to control gauge on a 4-high tandem mill, and being impressed by the number of possible variables with which they had to contend. For example, speed could markedly affect the gauge; strip tension also had a bearing on the matter; a variation in thickness of the stock could also be an important factor; variations in the distribution and/or quantity of the lubricant were not without effect; and, finally, there was the important question of thermal camber. Any developments on the lines suggested by Mr. Davies would not be likely to answer all gauge control problems and the same care would continue to be needed until all factors involved were brought under some form of automatic control.

Mr. Davies made it clear that brakes were fitted on cone decoilers to provide light back tension only and that must be kept in mind, in the case of aluminium rolling, as any attempt to use the cone decoiler as a back tensioning device invariably resulted in inter-face slip between the layers of the coil, which gave rise to minute though objectionable surface tears. The only safe way of dealing with back tension was to instal, between the cone decoiler and rolls, an independent means of achieving that, such as by the use of bridles or, on the slower speed mills, the use of substantial press boards.

Commenting on roll cooling and lubrication, Mr. Fowler mentioned an experience with a 2-high medium speed strip mill, which was not externally flood cooled. It was found that the thermal camber developed during the pass, with heavier coils, resulted not only in wide gauge variation, but in badly shaped strip. Reducing the rolling speed to a point at which the roll temperature became more or less stabilised gave some measure of success but adversely affected rolling tests. It was decided to reduce the camber to improve strip shape, and accept three passes instead of the two previously employed; it was found however, that the mill could be operated at full speed with the same reductions as previously and under much cooler conditions, and the gauge control and strip shape were excellent. It was thought that the conditions created were more favourable to the retention of the film strength of the oil, the net result being to reduce the friction of the roll/strip inter-face.

Mr. N. H. Polakowski, referring to the paper by Dr. Jevons, discussed reverse deep drawing with some of its direct implications. The superiority of that process over the orthodox unidirectional method has been expressed, but the reasons are said to be not understood. He suggested the reasons were rather simple and indicated them diagrammatically by experiments which showed that the outstanding difference between the two drawing methods lay in the different sequences and amplitudes of bending during re-drawing, and in their effect on the properties and behaviour of the pressed material.

Mr. A. B. Ashton discussed multi-die machines, for drawing copper and copper alloy wire at high speed, from the standpoint of lubrication. In the old days the lubricant was chosen for its lubricating properties only; the advent of the carbide die, however, and the subsequent development of high-speed multi-die drawing introduced the need for cooling. The heat generation in modern high speed drawing was very considerable; it arose from three main sources: the heat of deformation, frictional heat generated at the wire-die inter-faces, and frictional heat generated by "slip" on the cones or capstans. Thus, cooling had become a dominant consideration in wire-drawing machine design and facilities were provided for the copious application of aqueous soap solution to the whole of the working parts of a machine. Mr. Ashton suggested that lubricating properties had been sacrificed in the interests of cooling, and that attention should be given to the development of materials which had superior lubricating properties to those of the soap solutions used.

Mr. R. B. Sims (B.I.S.R.A.) endorsed Mr. Chisholm's view on the importance of strip lubricant on the cold-working of non-ferrous alloys, stressing the importance of its stability under rolling conditions. In rolling annealed mild steel, for instance, 0·03 in. thick and 1 in. wide at 50% reduction, a change in coefficient of friction (μ) from 0·08 to 0·12 would change the gauge by as much as 0·0025 in. The use of the most efficient lubricants resulted in a velvety matt finish, and it seemed that industry was prepared to accept inefficient lubrication for the sake of a polished finish. It would be interesting to hear of the experiments made by manufacturers to determine the rolling characteristics of their product, and also of their analyses.

Mr. Davies had raised the question of mill spring which had recently been examined in some detail at the B.I.S.R.A. experimental mill. The coefficient of elasticity M (load required to increase the roll separation by 1 in.) could be divided into two components, that due to the stretch of the housings, screws, etc., and that due to the bulk distortion of the rolls. The latter quality was defined as the reduction in the diameters of both rolls together in the arc of contact. Indications were obtained that even if a mill housing were infinitely

strong, there still remained the spring due to the roll distortion, a factor which might account for half the spring observed in the conventional mill. Mr. Davies had only hinted at the connection between mill spring and strip gauge. It could be shown that if F were the roll load, h the exit thickness of the strip, and S_o the initial roll setting at no load, then $F = M (h - S_o)$. If F, and S_o were held constant, then h, the strip thickness would be constant, regardless of variations in entry thickness, hardness and friction. A method of automatic gauge control had been based on that fact, but it could not, of course, control the periodic gauge error due to roll eccentricity.

Major P. C. Varley, confining his remarks to the paper by Dr. Jevons, commented on the advantage of using the metal slightly warm when deforming it in multi-punch presses, and said that in tests the tools were warmed up in an electric furnace to a temperature of 40–50° C. before putting them in the press. By the time the machine was ready for operation the tools had cooled to about 30° C. which seemed a useful temperature for carrying out the work. He emphasised the importance of close control of metal temperature in any inter-stage annealing process, particularly of aluminium. He wondered whether the possibilities of a stress-relieving or partial anneal had been fully explored. Enlarging on the drawing of a cylindrical cup in aluminium, he said a deeper draw was possible with annealed sheet if the punch had a hemispherical end than with half-hard or quarter-hard sheet, but the opposite result was often obtained if a flat-bottomed punch was used. The importance of keeping the tools in first-class condition was emphasised.

Mr. Wistreich intervened in the discussion to endorse what had been said about cooling and lubricating in wire drawing, and the difficulty of cooling the wire on the capstan and in the die. The wire was hottest the moment it left the die and, at present, no reliable measurements of the temperature at that point were available; from theoretical considerations, however, he described with the aid of slides what appeared to be the temperature distribution.

Mr. D. A. Barlow commented on a statement by Dr. Jevons that of the aluminium-magnesium alloys, the low-magnesium alloys behaved best under the press. He suggested that that would depend upon the type of operation, and would not always be the same, and emphasised his contention by slides showing some results of deep drawing tests.

Mr. R. Eborall referred to the formation of stretcher-strain markings in aluminium alloys, mentioned by Dr. Jevons, and said that the British Non-Ferrous Metals Research Association was engaged on the problem. Dr. Jevons expressed the opinion that metallurgists had drifted into the belief that the absence of a yield-point kink in the stress strain curves of the non-ferrous metals implied a freedom from susceptibility to such markings. In fact, in some aluminium alloys, a definite yield point, very similar to that occurring in steel could occur, and, by means of a slide, he showed the kind of curve obtained from a susceptible material.

Mr. A. T. Churchman commented on remarks made by Dr. Jevons in his paper, in which he suggested that scientists did not expect stretcher-strain in non-ferrous metals, as there were no yield kinks in the stress-strain curves of these materials. The work of many investigators was cited to refute this statement. Mr. Churchman suggested that stretcher-strains in some non-ferrous metals might be eliminated by excluding nitrogen from the metal or by some addition to the metal which would fix nitrogen, as titanium fixed carbon and nitrogen in steel.

Mr. Edwin Davies commented on certain metallurgical aspects, dealt with by Dr. Jevons, from the suppliers' point of view. He sympathised with the plea for co-operation between supplier and user, but too often the user did not know what was required. More research into the fundamental aspects of deep drawing operations must be carried out and, although this was a field for those primarily interested in making deep-drawn products, manufacturers of non-ferrous alloys would gladly co-operate.

Dr. Jevons had suggested that 70/30 brass work-hardened less rapidly than 63/37 brass, but, if the latter were free from the beta phase, as it was when supplied for deep drawing, the differences in the rate of work-hardening were negligible; Mr. Davies gave several examples. He could add little to Dr. Jevons' reference to season cracking, except to emphasise some points, and stated that imposing stresses, either in assembly or in service, might render brass products susceptible to season cracking even though previously stress-relieved by annealing.

Dr. H. Ford, who opened the afternoon discussion, referred to the two mechanisms of deformation mentioned by Drs. Cook and Richards, namely, slip within the crystals followed by some general shearing mechanism. Investigating by the cold rolling process they showed that the second mechanism set in at somewhere about 50% reduction in rolling. In recent experiments on high conductivity copper, in plain plastic deformation in compression, i.e. between two compression rolls, so that the material was deformed in plain strain—some effect was found which he thought was connected with the mechanism described. It was found, however, that the onset of the second mechanism could be delayed considerably and that, in fact, it did not set in until about 80% reduction by plain compression.

He thought the description of the mechanism of deformation in rolling, as given by Mr. Chisholm, a little over-simplified. There was no question of two rival and contradictory theories of rolling. It was a question of the geometry of the pass, of the magnitude of the tangential frictional drag between the strip and the roll, and the yield stress of the material as to whether slipping took place over the whole arc of contact, or whether there might be a small zone where the roll and the material went together. The viscosity of oils was not affected much by pressure, as pointed out by Mr. Chisholm, but it certainly was by temperature and that would have a considerable effect on the properties of the oils.

Mr. Egginton confined his contribution to the paper by Dr. Jevons which he thought might give the impression that 80/20 brasses were confined to press work. Such fine-grained brasses cupped from the blank satisfactorily to 40 to 50% cup reductions and drew well on such commercial layouts as one would normally consider for 70/30 brasses. Experiences at his works had shown that brasses of gilding composition had other advantages over brasses of the 70/30 type.

Professor H. W. Swift confined his remarks to two points, both related to the paper by Dr. Jevons. The two parts to which he drew attention were the section dealing with the tests for sheet metal and that concerned

with lubrication. He asked three questions relating to the first: how could the tensile test be interpreted to give really discriminating comparative information on drawability; what evidence of real correlation could be produced; and how could it be applied as an acceptance test? Of the wedge-drawing test, Dr. Jevons suggested that "if the results were considered in the light of long industrial experience, it would prove to be not less informative, and probably more discriminating, than the tensile test." He stated that investigators in Sheffield, among others, had failed to find reliable correlation. Inspection of the report, to which Dr. Jevons referred, suggested that the failure was a failure on the part of the test rather than on the part of the investigators; at Sheffield, in fact, they proved that there was a failure to correlate on the part of the wedge-drawing test.

On the subject of lubrication, he was not quite clear what were the "general" and what were the "vague" terms referred to by Dr. Jevons in quoting the work of other papers. In point of fact, he said, in Sheffield they had, for a number of years, been endeavouring to reduce the number of incommensurables which occurred in the problem of lubricant selection.

MR. LLOYD, in a preliminary reply, on behalf of Dr. Jevons, said a full reply to Professor Swift's remarks would be made in writing since it would call for a little paper on its own.

DR. SCHNURMAN referred to points in Mr. Chisholm's paper. One point concerned terminology and the definition of terms. When people talked about film strength of a lubricant, he wished they would explain the physical meaning of the film strength and how it could be measured. The other point concerned the function of a lubricant under metal rolling and wire-drawing conditions. He thought it most unlikely that there was any hydro-dynamic lubrication involved in metal working, and it would appear, therefore, that there was little point in looking at the viscosity pressure dependence of the lubricants; on the other hand, there was some point in considering the viscosity temperature dependence.

MR. W. J. THOMAS confined his remarks to the paper by Mr. Davies and spoke of the amazing developments in cold working plant in this country which, he thought, was due in a large measure to the closer co-operation between plant manufacturers and operators. Modern plants had taken away a lot of the skill of the operators and put the responsibility on to the plant designer and the plant superintendent. He thought it still remained a fact that the fundamental problem in cold rolling was the reduction of heat, whether from the bearings, friction between the strip and rolls, or the rolls themselves, and the prevention or controlled dissipation of such heat needed still further investigation. He believed that the rolling efficiency in most mills, taken on a week's operation, was still very low, due, in a measure, to the design of ancillary equipment for getting stock into and out of the mill quickly, and also to metallurgical problems; in connection with the latter he referred to the question of roll surface maintenance, flaw marks and other defects that developed during rolling, which caused operating delays.

MR R. LINFORD showed some figures of mill production efficiency and expressed gratification that Mr. Larke had referred to this subject, because although the designer should put reasonable care and consideration into the design of a mill, many other factors decided its operating efficiency. Such questions arose as: how good were the operators as a team; how good was the maintenance; how good was the team at roll-changing. Other questions included whether there was a good supply of incoming coils to the ingoing side of the mill—a material on gauge and good in every respect—and whether the material could be removed from the precincts of the mill quickly. One of the ways of increasing production efficiency and cutting down costs was to handle the pieces as few times as possible. He suggested a possible high production plant of the future and commented on the needs of the small man in the sheet and strip industry.

MR. SINGER thought that, on the application of lubricants to metal-working operations, some of the points raised by Mr. Chisholm might well guide future work. Much had been said about the coefficient of friction and values had been given, but he doubted whether their meaning was known and suggested that they were mostly overall values which happened to fit in fairly well with our simple analysis of what was going on during the rolling process; he thought a more penetrating analysis was very necessary to get fundamental knowledge of what was happening. He mentioned three methods and believed that most progress would be made by adopting direct experimental methods.

Replies of Authors

MR. S. F. CHISHOLM said there seemed to be some doubt in the minds of everyone as to what was meant by "film strength" and "lubricity." The terms were rather loose but he thought of a high film strength lubricant as being a lubricant that would prevent, to a great extent, metal-to-metal contact; a high degree of lubricity in a material referred to it being weak in shear. He emphasised that the viscosity of a lubricant was affected considerably by pressure and that variation in viscosity with pressure was something that should not be regarded too lightly. High viscosity index oils were not affected to anything like the same degree as low viscosity index oils. Although there was that wide variation in the effect that pressure had on the viscosity of oil, it applied to a greater extent in the case of fatty oils. That was the reason why fatty oils were so beneficial in many cold working operations.

DR. T. LL. RICHARDS said that the paper by Dr. Cook and himself was necessarily a very sketchy sort of background study of cold-working of metals. When considering the picture on a broad basis, they thought of three approaches: a fundamental study based on the electron theory of metals; a mathematical treatment of the type of the mathematical theory of plasticity; and the structural approach which was chosen.

In connection with the development of textures, probably flow had a more direct bearing than stress. Broadly speaking, a very general rule was that the change in shape was the change which determined texture; if wire were produced by drawing, swaging or simple tension, by and large the texture was very much the same. Referring to the slide shown by Mr. Wistreich, he had no doubt that Mr. Wistreich had the right explanation for the difference in tensile strength which was derived after very heavy reductions.

MR. H. J. MILLER said that Mr. Ashton obviously wished to see adopted dry-drawing. Adopting such drawing methods would enable improvements in lubricants to effect the actual reduction; to some extent

those principles had been incorporated in several machines. Machines, of the tandem type, were on the market, in which those conditions applied, i.e. real dry-drawing, or rather drawing with the aid of a very superior lubricant, the cooling being effected quite separately by the use of water-cooled dies and die-holders. He thought that the future trend in the fabrication of non-ferrous metals was more and more towards adopting steel drawing practice. Replying to a question by Mr. Davies about the rotation of dies, Mr. Miller said Mr. Cleaver had worked on that experimentally and had proved that, by suitably rotating the die at several hundred revolutions per minute, it was possible to obtain at least twice the output from the machine per mil. die wear. In America it was fairly general practice to produce rectangular section copper-wire, which was required in large quantities for motor windings. That was produced by rolling in a tandem set-up, there usually being three speeds ranging up to 1,500 ft./min. An interesting point in the set-up was that flying micrometers were used. A very large diameter clock dial was set off into one/ten-thousandths of an inch, which gave a ready check on any adjustment necessary. Mr. Miller said he was impressed with the real steadiness of the gauges and the facility with which they could be adjusted.

Mr. C. E. Davies on the question of automatic control, referred to by Mr. Hessenberg, said that the trouble with a lot of equipment of that sort, and also with load measuring devices—and he thought every mill should be fitted with a reliable load measuring instrument—was to obtain the equipment commercially. There were many load measuring devices that were quite satisfactory from the scientific point of view, but to get one capable of withstanding rough usage in the mill was not easy. Measuring by flying micrometers and the regulation of screwdown was fairly effective for control within the tolerances required, unless there were sudden changes which could not be corrected quickly. The opinion was expressed in the discussion that load deflection might account for as much as 50% of the total yield in the mill; he thought it would have been greater. It was true that such pre-loaded mills as had been developed did not take into account any deformation of the roll, but he did not see how that could be done.

Replying to Mr. Fowler, he said the housings of the pre-loaded mill were stressed much more highly than the ordinary mill. With the pre-loaded mill, apart from this question of deformation, a constant gauge should take care of variation in speed and the changes in entry gauge, which were two of the biggest causes of gauge variation. He was interested in Mr. Fowler's report of experience with the increasing rolling speed resulting in improved production and greater efficiency of working; he had always felt that high speeds were a good thing, especially for softer metals, and particularly for aluminium.

In conclusion, Mr. Davies referred to what Mr. Thomas had said about collaboration between the mill builder, the designer and user. Fortunately, in these enlightened days the operators in the producing firms were only too willing to co-operate with the designer. He thought that any wisely run firm in these days would always wish to co-operate by telling the mill builder exactly what it wanted, although, unfortunately, in some cases the mill builder might not be able to do it.

The B.I.F—*Continued from page* 184.
indicator, draught gauges, flowmeters and electronic controllers and recorders. There will also be shown a supersonic flaw detector, a dynamic strain recorder, a portable temperature indicator and various thermocouples.

An essential feature of the De La Rue stand (D757/656) will be an octagonal drying tunnel, 9 ft. in length, incoporating 18 Potterton gas-fired infra-red panels and fitted with a monorail conveyor with variable speed drive. Temperatures of up to 750 ° F. may be obtained in the tunnel and this normally provides a margin of extreme value when really heavy articles, such as, iron castings, are required to be dried.

New products shown for the first time on Stand B221 (Jenolite, Ltd.) will include a decarbonising solution for removing carbon deposits from internal combustion engine valves, and an aluminium ornamental etchant which imparts an artistic finish to aluminium surfaces. Other exhibits will include Jenolite R.R.N.1. (rust remover and neutraliser), and the new aluminium degreaser and cleaner.

The industrial uses of magnetic devices is increasing rapidly for such purposes as lifting steel plates, bars, scrap, etc.; sand cleaning by separating tramp iron; concentrating magnetic materials such as ore; holding steel and iron components for grinding and machining; transmission clutches, etc. Each year sees fresh developments in this field, and those interested should visit Stands C421 and C605 where can be seen the exhibits of Rapid Magnetic Machines, Ltd. and Electro-magnets, Ltd., respectively.

In addition to their general stock of power transmission equipment, Crofts (Engineers), Ltd. (D343/238), will feature a number of special exhibits. These will include the "Ritespeed" Geared Motors and Reduction Gear; their patented B.O.M.-L. Clutch which will interest machine tool makers; Split Taper Bushed V-Pulleys (a recent development); and a representative display of heavy engineering transmission equipment.

Of interest to those planning new factories, or improving existing ones, will be the exhibits on Stand 615/512, where Hills (West Bromwich), Ltd., will be showing their permanent steel-framed school construction; lead and aluminium roof glazing; metal windows and doors; and similar products. Of special interest for metal working shops will be the ventilating shutters which provide what is virtually a movable roof.

On Stand D755/654, Keith Blackman, Ltd., will be exhibiting "Tornado" fan engineering equipment for a variety of purposes such as ventilation, dust extraction, boosting gas and air pressures, and space heating.

The metal powders displayed by George Cohen, Sons & Co., Ltd., in the 600 Group Pavilion, will include Sintrex Metallurgical Iron Powder; Sintrex Electrolytic Iron Powder, which, by virtue of its purity, is widely used in electromagnetic applications; and Sintrex Grey Iron Powder, of which the finer mesh gradings are used as a reducing agent for organic compounds, while the coarser gradings find application in concrete floor hardening.

Although the development is in its early stages, P.M. Process Parts—made by powder metallurgy—will be shown by John Rigby & Sons, Ltd., on Stand D607. They have good mechanical strength and can be oil-impregnated if necessary.

NEWS AND ANNOUNCEMENTS

Iron and Steel Institute

Annual General Meeting

The Annual General Meeting of the Iron and Steel Institute will be held in the Institute's Offices, 4, Grosvenor Gardens, London, S.W.1., on Wednesday, Thursday and Friday, May 30th and 31st, and June 1st, 1951. On the Wednesday evening, a Members' Dinner will be held at the Dorchester Hotel, Park Lane.

After the formal business meeting, at which the various medals awarded during the year will be presented, the new President, Mr. Richard Mather, will take office and deliver his Presidential Address. The remainder of the first morning's session will be devoted to discussion of a paper on "The Present Position of the Converter Process in Economic Comparison with other Steelmaking Processes."

In the remainder of the technical sessions, the papers to be discussed concern blast furnace practice and will be opened with the presentation of films by Dr. J. B. Austin on "Study of the Zone in Front of a Blast-Furnace Tuyere by Means of High Speed Motion Pictures and Models." This will be followed by a discussion on "Significance of Equilibrium and Reaction Rates in the Blast-Furnace Process." Other papers to be presented for discussion on the second day will include: "Aspects of the Blast Furnace Situation in the U.S.A."; "Evolution of the All-Carbon Blast Furnace"; "Radio-active Indicators for Blast Furnace Refractory Wear"; "The Smidth Agglomerating Kiln—Plant and Practice at East Moors Works, Cardiff"; "Sinter Making at Appleby-Frodingham"; "Investigation of Controlled Variables on Sinter Quality. Part I—Development of Experimental Sinter Plant and Preliminary Results using Northants Ore"; and "The Sintering of Northamptonshire Iron Ore—a Production-Plant Study of Factors Affecting Sinter Quality." The proceedings on the final day will be confined to a morning session when two papers will be discussed: "Full-scale Blast-Furnace Trials"; and "Distribution of Materials in the Blast Furnace. Part III—Further Factors Influencing the Distribution of Solids in the Blast-Furnace."

Iron and Steel Productivity Team

An Iron and Steel Productivity Team, covering Pig Iron and Heavy Steel, will be sailing on May 17th for a six weeks' visit to the United States under the auspices of the Anglo-American Council on Productivity, with E.C.A. technical assistance. The Team will study and report on the organisation and methods of the U.S. Iron and Steel Industry. It will also consider the factors bearing on the comparative productivity of the U.K. and U.S. industries, and recommend whether and by what methods U.S. experience can with benefit be applied or adapted in this country. Much is already known here about the American Industry, whose scale, raw materials and markets are, of course, very different from our own. It is, however, felt that a fuller interchange of information and a first-hand study of the relevant wide variations of practice and conditions to be found in the U.S. will be of benefit to development in this country.

The Leader of the Team will be Sir Charles Goodeve, F.R.S., Director of the British Iron and Steel Research Association, and the Deputy Leader Mr. S. Thomson, Executive Director, Colvilles, Ltd., and General Manager, Dalzell and Lanarkshire Steel Works. The other Members selected are:—Mr. L. E. Ayre, Blowing Engine Driver, Appleby-Frodingham Steel Co.; Mr. A. Braddock, Rail Bank Superintendent, Cargo Fleet Iron Co.; Mr. A. Bridge, Chief Ironworks Engineer, Appleby-Frodingham Steel Co.; Mr. J. L. Davies, First Hand Melter, English Steel Corporation; Mr. G. Foster, Development Engineer, Dorman, Long & Co.; Mr. B. S. Keeling, Secretary, British Iron & Steel Federation (Team Secretary); Mr. D. Kilby, Melting Shop Manager, Colvilles, Ltd. (Clydebridge Steel Works); Mr. M. Leahy, First Hand Melter, Guest Keen Baldwins Iron & Steel Co.; Mr. C. E. Lupton, Cost Accountant, Steel, Peech & Tozer; Dr. D. F. Marshall, Fuel & Refractories Officer, Park Gate Iron & Steel Co.; Mr. E. T. Sara, Economist, United Steel Companies; Mr. I. S. Scott-Maxwell, Technical Officer, British Iron & Steel Federation; Mr. J. Wadsworth, Staff and Labour Superintendent, Park Gate Iron & Steel Co.; Mr. W. Ward, Cogging Mill Racks Operator, Colvilles, Ltd. (Clydebridge Steel Works).

B.W.R.A. Summer School

The British Welding Research Association is to hold a Summer School on "Welding Design and Engineering" at Ashorne Hill, near Leamington Spa, from Friday, May 25th to Saturday, June 2nd, 1951, inclusive. The Association hopes by this means to acquaint the practical man with up-to-date welding developments, to stimulate the application in industry of experimental knowledge and experience, and to describe the present state of knowledge relating to some of the fundamental welding problems.

The first two days will be devoted to discussion of recent developments in welding practice and metallurgical aspects of welding ferrous and non-ferrous metals. This will be followed by five and a half days devoted to general lectures, commencing with morning sessions on welding problems such as (a) Welded Structures Under Fatigue Loading, (b) The Problem of Brittle Fracture, (c) Residual Stresses in Welded Structures, etc. In the afternoons, specialised lectures, comprising four main groups:—(1) Structures, (2) Pressure Vessels, (3) Ships, and (4) General Engineering and Machinery, will be given. The latest applications of existing knowledge will be discussed, as for instance in (1) the plastic behaviour of welded structures; in (2) the stresses in the design of pressure vessels and pipelines; in (3) the application of experimental stress analysis to ships. There will be evening discussions opened by experts in the particular field, on general topics of importance to welding engineers.

The lectures will be given by men renowned either in the welding industry or universities, together with members of the staff of B.W.R.A. This school will prove to be of the utmost importance to those connected with any of the many applications of welding, and as vacancies are limited, it is suggested that employers who wish to send members of their staff, or individuals

who wish to attend, should communicate with the Secretary, British Welding Research Association, 29, Park Crescent, London, W.1, as soon as possible, requesting the necessary application form and full particulars.

Lincoln Cinema

A WELL-EQUIPPED cinema can be found in the Lincoln Electric Co., Ltd.'s establishment at Welwyn Garden City. Planned as part of the Lincoln training scheme for welders—this cinema seats over 20 student welders and is of excellent technical value in that it is able to show, through its Bell & Howell-Gaumont 16 mm. sound projector, a series of Lincoln films, mostly in technicolour, covering arc welding fabrication almost from start to finish.

This type of cinema offers two advantages in that it is also useful as a lecture room where students assemble for discussions on arc welding subjects given by welding instructors. Other interesting features are the display of Lincoln arc welding equipment and the examples of welding fabrications that are always at hand for demonstration. A stillograph which is electrically operated, revolves 11 photographs on various welded subjects and is also very helpful to the student welder.

The Lincoln Electric Co., Ltd., will gladly lend any of the following films for showing: THE MAGIC WAND OF INDUSTRY; PREVENTION AND CONTROL OF DISTORTION; DESIGN FOR ARC WELDED STRUCTURES; DESIGNING MACHINERY FOR ARC WELDING; WELDING COMES TO THE FARM.

Maximum Prices for Secondary Aluminium

THE Federation of Secondary Light Metal Smelters announces that, following the introduction of the Aluminium Scrap Prices Order, 1951, and, as there is no similar order for secondary aluminium alloy ingots, its members, with the approval of the Ministry of Supply, and with the object of stabilising price levels, have decided to adopt a range of maximum selling prices for their alloys. They have agreed, therefore, that from April 9th, 1951, the following will be adopted as the maximum prices for the undermentioned alloys delivered to buyers' works:—

L.M.1, £128 per ton; L.M.2, £145 per ton; L.M.4, £132 per ton; L.M.6, £155 per ton.

Deoxidising Sticks 85/90, £115 per ton.

The prices of other alloys will be related to the above.

These maximum selling prices are based on the present prices of raw materials and current production costs. Should it become necessary to alter them, a further announcement will be made. It is hoped that consumers will co-operate with the Federation in its endeavour to stabilise selling prices at a reasonable level.

Institution of Works Managers

Directory of Members

THE Institution of Works Managers had recently published a new directory of members. This gives details of the positions held by its members, whose names are arranged alphabetically. The last directory was issued four years ago, since when the membership of the Institution has trebled and since when the merger between the Institution of Factory Managers and the Institution of Works Managers has been consolidated. The new directory will therefore be an invaluable reference work for members of the Institution and others. Copies can be obtained from the offices of the Institution at 67-8, Chandos Place, London, W.C.2, at 10s. 6d. each.

Stordy Engineering Ltd.

STORDY ENGINEERING, LTD., thermal and mechanical engineers, manufacturers of furnaces, industrial ovens and metal finishing plant, have now moved to more commodious premises. The new address will provide increased accommodation for design and administrative staff, and there will be greater facilities for handling increasing number of orders.

The new address is: Cumbria House, Goldthorn Hill, Wolverhampton, (Tel.: Wolverhampton 37341–2).

Personal News

IT has been announced by The Sheepbridge Co., Ltd., Chesterfield, that MR. E. MARVILL has been appointed General Manager to the Company. During the past year, Mr. Marvill has been in the control of all installation work carried out in connection with the Company's new blast-furnace plant reconstruction scheme.

MR. D. L. CAMPBELL, M.C., has been appointed a Director of the Electric Furnace Co., Ltd.

MR. L. PERRETT, has been elected President of the Swansea and District Metallurgical Society for the Session 1951/52.

MR. GEORGE KELWAY has been appointed Birmingham Area Manager for A. C. Wickman, Ltd., in succession to MR. C. R. PERKS, who is leaving this country shortly to establish and manage a new A. C. Wickman Branch Factory at Mentone, Melbourne, Australia.

MR. E. J. LOWE and MR. E. WILSON HAGUE have been appointed Directors of Thos. Firth and John Brown, Ltd.

FOUR members have been appointed to the Steel (Rearmament) Advisory Panel, of which Mr. E. W. Senior is Chairman. They are MR. C. E. HOLMSTROM, MR. C. MUIRHEAD, MR. W. E. A. REDFEARN and DR. C. SYKES. Mr. Muirhead and Mr. Redfearn are Special Directors of English Steel Corporation, Ltd., Mr. Holmstrom is Managing Director of Firth-Vickers Stainless Steels, Ltd., and Dr. C. Sykes is Deputy Managing Director of Thos. Firth and John Brown, Ltd.

MR. D. D. PRATT, Acting Director of the Chemical Research Laboratory, Teddington, has been appointed Director.

DR. E. C. ROLLASON has been appointed to the Chair of Metallurgy at Liverpool University.

Obituary

IT is with regret that we announce the death, at his home in Swansea on April 9th, of Mr. Harry Davies, Technical Manager, Imperial Chemical Industries, Ltd., Metals Division, Landore, Swansea. At the time of his death, Mr. Davies was a Member of the Council of the Institute of Metals, having been elected to that office in March, 1950.

WE regret to announce the death on April 3rd of Mr. Sidney Wolfe, founder of Wolf Electric Tools, Ltd., and, until his recent resignation on the grounds of ill-health, Chairman of the Board and Governing Director.

LABORATORY METHODS

MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC

INSTRUMENTS AND MATERIALS

APRIL, 1951 Vol. XLIII, No. 258

The British Industries Fair at Olympia

Laboratory Equipment on Show

Although on a smaller scale than in former years, a display of laboratory equipment and scientific instruments will be a feature of the Olympia section of the British Industries Fair which will be held this year from April 30th to May 11th. A brief account of some of the exhibits which are likely to be of interest to readers is presented in the following pages.

THE scientific instrument display at the Olympia section of the British Industries Fair will be on a smaller scale than in former years. No doubt this is a result of the decision to hold a British Instrument Industries Exhibition in July, and the combination of this and the instrument section of the B.I.F. will provide a very comprehensive display of instruments. Recent years have seen a considerable increase in instrumentation in many industries, the instrumentation of the open-hearth steel furnace providing a notable example. Moreover, there has also been a considerable increase in scientific research and routine control, for which a variety of items of laboratory equipment have been devised with a view to increasing the efficiency of the available scientific manpower. In the following pages we present brief details of some of the exhibits likely to prove of interest to readers. Unless otherwise stated, the stands are on the ground floor at Olympia.

W. & R. Balston, Ltd.—Stand D.38.

The exhibits this year will include the whole range of Whatman high-grade filter papers, of which the ashless and hardened-ashless grades are of particular interest in metallurgical analysis.

Of special interest to metallurgists is a new product—Whatman "Ashless" Cellulose Powder. This is used in columns for a variety of chromatographic separations and, in particular, for analysis of metallic ores and alloys, and for the preparation of pure specimens of inorganic salts. A suitable solution of the ore or alloy is applied to the top of the column and eluted with an organic solvent. In the course of their migration through the column, one or more of the metallic ions may be isolated from the rest, and by collecting consecutive fractions of eluate from the column the amounts present may be determined. In the case of coloured ions, qualitative analyses may be followed visually.

The Whatman filter papers are also used for the technique of "filter paper chromatography" which has been applied considerably to qualitative and quantitative inorganic separations. In this method, the inorganic substances are located on the chromatgram by spraying it with suitable colour reagents. It is hoped to display a column of the powder showing a typical inorganic separation and various photographs of the paper chromatgrams.

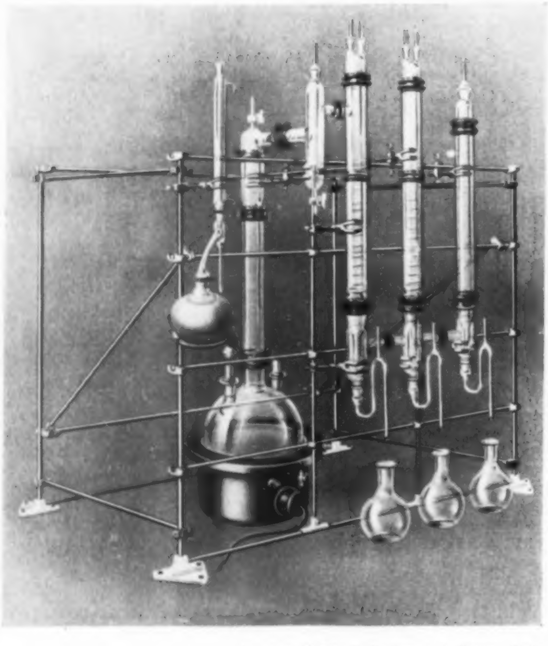
The British Rototherm Co., Ltd.—Stand D.46.

This Company will be exhibiting a comprehensive range of bi-metallic and mercury-in-steel instruments for indicating, recording and controlling temperature. The heavy industrial bi-metallic thermometers are designed for use where robustness is required. They include instruments of the co-axial, vertical, and flange types which are manufactured to indicate temperatures as low as 100° F., and as high as 1,000° F., with 2¼ in., 4 in. or 7 in. dials, and 16 standard temperature ranges for each size. Thermometers fitted with contact heads to provide on/off control when used with a suitable relay will be exhibited.

Courtesy of The British Rototherm Co., Ltd.

Mercury in Steel Temperature Recorder.

Also on show will be two recently developed mercury-in-steel indicating temperature controllers, suitable for operation in the range—30° F. to 1,100° F. which can be relied on for accuracy and stability. They can be fitted with maximum and minimum contacts for on/off control, the differential being variable between full scale and a minimum of 1% of the scale range, or with a zero differential on/off control fitted with either maximum or minimum contacts but not both. The exhibition will be completed with a display of light industrial instruments.



Courtesy of W. & J. George & Becker, Ltd.

"Kemiframe" supporting a Dean and Stark Apparatus.

Doulton & Co., Ltd.—Stand D.24

In addition to such generally known articles of laboratory porcelain as evaporating basins and crucibles, the exhibits on this stand will include porcelain bunsen burners, ball-mills, mortars and pestles, and such items as mercury troughs, staining troughs and various shapes of spatula made in Royal Doulton porcelain whose chemical inertness, heat resistance and mechanical strength render it an ideal material for the manufacture of such articles. In addition to the normal high-quality porcelain which is rigorously tested to exacting standards, a limited range of Circle S Ware laboratory porcelain suitable for students and routine use in schools, universities, general laboratories, etc., will also be shown.

Evans Electroselenium, Ltd.—Stand D.9.

The three principal exhibits on this stand will be the EEL Portable Colorimeter, the EEL Absorptiometer, and the EEL Universal Densitometer. The first named provides a simple photo-electric means of accurately assessing the colour density of a liquid; ⅝ in., ½ in., and ¼ in. test tubes can be provided suitable for use with this instrument.

The absorptiometer is designed to give accurate readings of the colour density of liquid samples. It enables the speedy plotting of a spectral distribution curve of a sample solution, and control can thus be maintained over each colour, enabling standard colours to be produced and maintained. Turbidity, opacity and trace elements can also be easily and accurately determined.

The densitometer is an instrument of robust design, intended for routine measurement of the optical densities of photographic films. Three aperture sizes are provided and readings may be made on wet or dry negatives up to densities of three on three ranges.

W. & J. George & Becker, Ltd.—Stand D.33.

Among other exhibits on this stand, W. & J. George & Becker, Ltd., will demonstrate the industrial application of their "Kemiframe"—a system of particular appeal to the laboratory research manager who is faced with the problem and expense of providing elaborate apparatus which may be required for only a limited period. It comprises a series of ½-in. dia. steel rods which can be connected at right angles by special connnectors, and a series of wall and floor clamps and other standardised fittings from which can be built up a solid frame for permanent or semi-permanent set-ups. The illustration shows a continuous distillation plant with a Dean and Stark's apparatus on a "Kemiframe" 6 ft. square by 30 in. deep.

Shown for the first time will be the Nivoc Polarimeter (N.D.220) a completely reliable educational model which can also be used for practical measurements. The optical system employs polaroid discs in the polariser and analyser, and a condensing lens in the polarising system to ensure parallelism of the light passing down the solution tube. A 20 cm. solution tube, with air bubble trap is fitted as standard but 10 cm. tubes are available if required. The instrument measures 13½ in. in height and is 15 in. long overall. It is finished throughout in grey enamel, and all bright parts are nickel plated.

Glass Developments, Ltd.—Stand D.22.

Those concerned with the non-destructive testing of metal parts will find considerable interest in the ultrasonic flaw detector demonstrated on this stand. Portable equipment is used to produce an image on a cathode-ray tube, of a section through a sample, so as to give a picture of any flaws. The method of presentation is different from that normally adopted, in that the

Courtesy of Hanovia, Ltd.

The Hanovia fluorescence lamp (Model 15). The burner above is shown as handled for testing, being returned to its ring after use. The quartz arc tube is in the body; part of the fluorescence filter can be seen through the opening.

echoes, instead of being made to deflect the time base vertically, are used to brighten it. The controls are so adjusted that, in the absence of an echo, the tube face is dark, and the signal from an echo will produce a bright spot. In this way a bright spot will appear at the moment of transmission, and again when an echo is received, either from the boundary, or from any flaws or other reflecting target. The probes are moved along the specimen surface and the time base is made to move vertically across the face of the tube in synchronism with the probe movement. As the probes move over a flawed region, a bright patch appears on the tube face in a position determined by the depth of the flaw and the position of the probes, and in this way an " ultrasonic " image of the specimen is built up on the tube face. A persistent-type screen is used and the image remains long enough for the operator to locate the position of the flaws. It is claimed that this method of presenting the data obtained from ultrasonic apparatus has considerable advantages over methods used hitherto.

Hanovia, Ltd.—Stand D.30.

This Company, which specialises in ultra-violet ray lamps, will have on show a range of equipment for various technical applications of ultra-violet light. Of special interest to metallurgists will be a new development, the Fluorescence Lamp, Model 15, which has not previously been exhibited. Fluoresence lamps are familiar, but the innovation in this model is that it is entirely portable and so enables the lamp to be taken to the work instead of (as hitherto) the work to the lamp. First designed for tracing leaks in condensers and refrigeration units, it is proving particularly useful in connection with the well-known " Glo-Crack " process for detecting flaws, and we understand that co-operative marketing arrangements for this unit have been made with Messrs. C. Tennant, Sons & Co., Ltd., who are selling agents for the " Glo-Crack " process on behalf of Colloidal Research Laboratories, Ltd.

May & Baker, Ltd.—Stand B.25.

The M. & B. stand will emphasise the application of M. & B. products in a wide range of human activities. The display will show by means of monochrome photographs and coloured transparencies the uses of these products. For the photographer a number of developers

Courtesy of Taylor Electrical Instruments, Ltd.

Windsor Universal Meter—Model 88A.

Courtesy of May & Baker, Ltd.

" Ethulon " plastic tracing film.

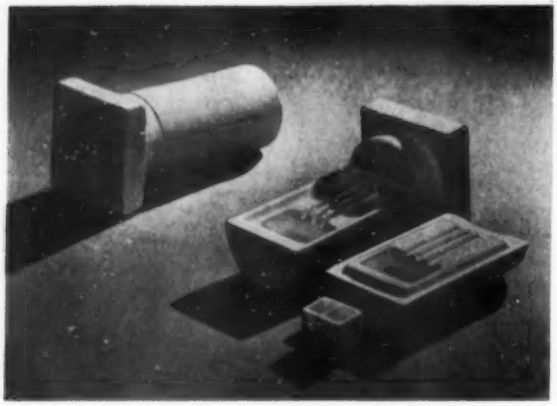
will be featured. These have been referred to in our columns in recent issues, but brief reference may be made to them here. " Promicrol " is a fine grain developer which gives the maximum emulsion speed consistent with very fine grain, whilst " Cobrol " is a concentrated bromide paper developer which gives clear bright prints over a wide range of development times. For users of document copying machines, " Planocop " is a new developer which has been formulated to give images of good contrast and density with an exceptionally low fog level. Among M. & B. plastics, " Ethulon " tracing film is of particular interest to the printing and allied trade, and for general drawing office work. The film is extremely translucent, so that individual tracings can be made in line colour separations, affording a quick and accurate check of visual register. " Ethulon " has a low coefficient of thermal expansion and does not discolour or embrittle with age. Ink adheres well to the fine-textured matt upper surface and erasure is readily effected by the usual razor-blade technique.

Quickfit & Quartz, Ltd.—Stand L.62, First Floor.

On this stand will be seen examples of laboratory and full plant scale equipment assembled from interchangeable glass units. Laboratory apparatus will include new items such as a spinning-band fractionating still; various chromatographic adsorption columns and assemblies; a climbing film evaporator; latest type of soxhlet extractor and stirring gear. Space limitations prevent the inclusion of full-scale chemical plant, but a vacuum still is displayed with 6 in. bore vapour pipe; a 100-litre electrically heated reaction vessel; and a production scale soxhlet extractor. An interesting exhibit will be a scale model of the sulphuric acid absorption plant. The difficulty of presenting examples of full scale plant is demonstrated by the model, which is $\frac{1}{12}$th scale and stands 4 ft. high. Sections of 18 in. bore column, and a 200-litre flask will also be shown.

Sangamo Weston, Ltd.—Stand D.43.

A representative range of Weston electrical measuring instruments will be on show, including laboratory standards, portable instruments, first grade instruments, D.C. galvanometers and frequency meters. The Model S.75 multi-range test set has 53 ranges and measures A.C. and D.C. current, voltage, resistance and insulation,



Courtesy of The Thermal Syndicate, Ltd.

Thermal analysis apparatus in fused alumina (Roberts and Grimshaw pattern).

whilst the radio-analyser consists of a portable multi-range test set having a sensitivity of 20,000 ohms per volt on all D.C. ranges, and 1,000 ohms per volt on all A.C. ranges. A range of panel and switchboard instruments will also be displayed. Other exhibits of interest will include the range of Sangamo synchronous motors and time switches, photo-electric photometers and exposure meters, and a range of aircraft instruments.

Taylor Electrical Instruments, Ltd.—Stand D.56.

Included in instruments made by this Company, many of which will be displayed on the stand, are valve voltmeters, capacity resistance bridges, circuit analysers, valve testers, television pattern generators, television wobbulators, signal generators, audio-oscillators, cathode ray oscillographs, insulator testers, output meters, and a number of universal multi-range meters. Available for the first time in 1951, three new multi-range meters will be shown. The Model 72A has 24 ranges and British Standard first grade accuracy on all the ranges which cover 0–750 volts (A.C. and D.C.), 0–15 amps (A.C. and D.C.), and 1 ohm to 500 kilohms. The Model 77A has an accuracy of 2% of full scale on D.C. ranges (except 3 kV.), 4% on A.C. ranges and 3% on the 3 kV. range. The 24 ranges cover 0–3,000 volts D.C., 0–750 volts A.C., 0–15 amps. D.C., and 10 ohms–5 megohms. Both these models have a buzzer for continuity testing and output as A.C. volt ranges via a condenser. The Model 88A has an accuracy of 2% of full scale on all the D.C. ranges but the 5 kV range, 4% on A.C. range, and 6% on the 5 kV range. The 85 ranges cover 0–5,000 volts (A.C. and D.C.), 0–10 amps. (A.C. and D.C.), 1 ohm–5 megohms, − 30 to + 55 decibels, 0·2–1,000 henrys, and 200 pF to 100μF, the last two by the use of external adaptors. A buzzer is provided for continuity testing and output is as the A.C. volt ranges via a condenser, except 5,000 volts. Adaptors are available for high voltage D.C. readings, high current A.C. and D.C. readings and low and high resistance readings.

The Thermal Syndicate, Ltd.—Stand D.8.

In addition to exhibiting heat- and acid-resisting Vitreosil (pure fused quartz and silica) crucibles, basins, beakers, etc., for general laboratory use, a number of specific items of Vitreosil laboratory-ware will be on display. These will include specimen tubes for use in the powder method of X-ray diffraction analysis, mercury vapour pumps, mercury vapour lamps, absorption cells for use in spectrophotometry, filtering and ignition crucibles fitted with porous discs, and optical quality fused quartz lenses, prisms, etc. Industrial Vitreosil ware will include apparatus used in acid plants, and the Vitreosil electric immersion heaters for use in plating and acid pickling tanks.

For use at temperatures above 1,100° C. (the normal upper limit for Vitreosil) Thermal Mullite ware and combustion tubes will be shown together with Thermal Zircon ware and a range of pure oxide refractory ware in fused and recrystallised alumina, fused magnesia, thoria and zirconia, possessing special characteristics and physical properties suitable for use in many cases at temperatures above 2,000° C.

The Tintometer, Ltd.—Stand D.55.

Throughout the period of the Fair the Lovibond Tintometer and the Lovibond Schofield apparatus will be demonstrated and representatives will be available to discuss colour problems with manufacturers. The new improved type Lovibond Comparator will also be displayed, and an even wider range of the discs of glass colour standards. The complete Lovibond *p*H Testing Kit, covering the range from 3 to 11 in steps of 0·2 has been redesigned to incorporate the new type Lovibond Comparator. A selection of OGAL brand fused glass cells will also be on view.

Thomas Tyrer & Co., Ltd.—Stand B.2.

Of interest to the metallurgist on this stand will be the examples of the well-known "C.R." chemicals which are guaranteed to pass a published standard of purity, suitable for analysis and research. A number of "Sterling" Brand chemicals made by this company are of interest directly and indirectly. These include chromates and phosphates, used for corrosion inhibition, plating salts, strontium salts, and antimony and arsenic compounds used in metal finishing.

The Arc-Welding Process

New Film by Quasi-Arc

THE Quasi-Arc Co., Ltd., Bilston, Staffordshire, announce that they have produced a new film "Arc Welding" having a running time of about 20 minutes. The film is 16mm. sound and printed in colour, and has been produced in response to demands for an instructive film giving information on the arc welding process for the wide number of engineering audiences who come in contact with welding but have no detailed knowledge of it.

With the aid of animated diagrams it shows the way in which a weld is made and the principles to be followed to ensure that sound welds can always be produced. It also deals with the type of equipment used, how welding operators are trained, the method of manufacturing arc welding electrodes to ensure consistency and reliability, and the testing of finished welds.

The use of electric welding has risen to prominence in the fabrication of almost all products made from ferrous and non-ferrous metals, and a number of examples of the types of engineering products designed for welded fabrications are shown—ships, boilers, bridges, vehicles, etc. Knowledge of welding is now more in demand for the armament programme, and this film is being widely shown to engineering institutions, technical colleges and works' groups.

The Study of Dusts in Industrial Atmospheres

2—The Konimeter and Jet Sampling Instruments

By P. F. Holt, B.Sc., Ph.D., D.I.C., F.R.I.C.

University of Reading

In the first of this series of articles, published last month, the author described the thermal precipitator and its use in determining the particle count of a dusty atmosphere. He now proceeds to discuss the konimeter and the jet dust counter, which, though not giving the absolute accuracy of the thermal precipitator, are more convenient for routine observations.

THE thermal precipitator is probably the most accurate instrument which can easily be used in the field for the determination of particle count. Its accuracy has been investigated by comparing counts on thermal precipitator samples with absolute measurements made on the same atmosphere with a special ultra-microscope and with a sedimentation cell. This latter is a hollow cylinder which can be closed at both ends by glass plates and it is used to enclose a sample of the dusty air, the volume of which will be equal to that of the cylinder. The dust is allowed to settle over a long period on to one of the glass plates and it is then counted under the microscope. This apparatus cannot of course, be used in large-scale investigations.

Fig. 1.—Sketch of the Zeiss konimeter.

Certain inaccuracies which arise when the thermal precipitator is used have been pointed out ; for example, a small count is obtained when the instrument is switched on, even if no air is drawn through the apparatus. Its efficiency when dealing with particles larger then 8 microns has been questioned. However, these errors are probably insignificant in most investigations.

The Konimeter

As the thermal precipitator is a somewhat delicate instrument and requires an accumulator as a source of current, it may be found somewhat cumbersome for taking large numbers of routine samples. Of the several types of dust sampling apparatus which are available for routine observations, but which do not give the absolute accuracy of the thermal precipitator, the konimeter has proved very popular in South Africa where dust investigations have proceeded on a considerable scale, because of the incidence of silicosis in the gold and other metalliferous mines. There are several designs of this instrument but all work on the same principle, that a measured volume of air is drawn through a narrow orifice by means of a hand- or motor-driven pump, and is made to impinge on a slide coated with glycerine. The dust is retained by the glycerine film as a tiny circle or narrow band and the particles are counted with the aid of a microscope fitted with a graticule. One design of this instrument is illustrated in Figs. 1 and 2. In some models the microscope is built into the instrument so that the whole is carried as one unit and, if required, estimations can be made immediately after the samples have been taken.

Konimeter samples are usually counted using dark ground illumination and, under favourable conditions,

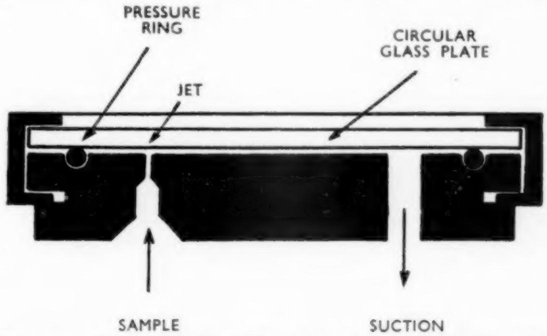


Fig. 2.—Diagram of konimeter constructed to take multiple samples on one plate. Suction is provided by means of a hand or spring operated pump.

tests have shown that 50–60% of particles are collected in dust clouds containing from 500–2,300 particles per ml. The usual method of counting does not reveal particles smaller than 0·8 micron diameter. With certain dusts, such as sand and sandstone dusts, it is not possible to use dark ground illumination because of the scattering of light from large particles and aggregations of particles. In this case, direct illumination must be used and the efficiency of the count is lower, say about 40%. Again, the efficiency varies according to the size of the dust particles present and, when the dust cloud contains a large number of small particles, many of these are not collected by the konimeter ; the efficiency is then considerably lower. Tests in the Witwatersrand Mines have shown that, whereas determinations made with the konimeter gave values some 60% of those obtained with the thermal precipitator or sedimentation cell when the number of particles was approximately 500 per ml., this value dropped to only 30% when the number of particles was 4,000 per ml.

The highest efficiency is obtained with the konimeter if care is taken that the instrument is in good adjustment. Particular attention must be paid to the following points. The konimeter should be adjusted to avoid leakage and to secure correct jet adjustment and velocity of impingement. Care must also be taken to ensure that there is no contamination of the slide.

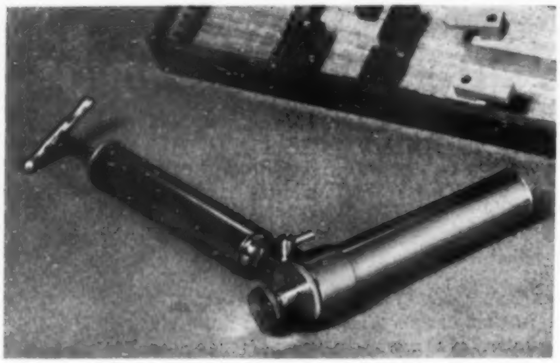


Fig. 3.—Owen jet apparatus.

The microscope must be carefully adjusted to secure maximum visibility of the smaller particles and all visible particles must be counted.

Although it will be seen that the konimeter has considerable limitations, it has proved a very valuable instrument in dust control work. Its absolute accuracy is not high, but serial samples are comparable one with another and, provided that proper precautions are taken, its performance is consistent. In most control work an absolute evaluation of the dustiness is not required; it is necessary only to determine the relative dustiness of certain processes or the degree of reduction when, for example, new ventilation methods are tried.

THE JET DUST COUNTER

The konimeter was developed some forty years ago; it has found considerable application and is still widely used. Another ingenious dust sampling apparatus, described by Dr. J. S. Owens, in 1922, is the jet apparatus Fig. 3. It resembles the konimeter in that a measured volume of the dust laden air is forced by means of a hand pump through a minute slit so that it impinges on to a glass plate. It differs from the konimeter in that the air passes through a damping chamber before reaching the slit so that it becomes saturated with moisture. In this case the dust adheres to the glass surface without an adhesive. Owens suggested that the effectiveness of this apparatus was due to the fact that, after passing through the slit, the pressure of the air is suddenly reduced, its temperature drops and moisture condenses around the dust nuclei, these particles remaining attached to the glass plate. After the sample has been taken, the temperature in the chamber rises and the water evaporates leaving a tiny ribbon-shaped dust deposit. The particles are counted with the high-power microscope.

Green and Watson considered that the efficiency of the jet dust counter was of the order of 40% and they found that the instrument was selective, collecting particles smaller than 0·5 micron most readily but allowing many larger particles to escape. Other workers have considered that the efficiency is much higher than this value; some have stated that, properly used, the instrument gives counts nearly identical with those obtained by sampling the same atmosphere with the thermal precipitator. To obtain records for dust control, the apparatus is particularly convenient because of its light and compact form. It is easily handled and easily maintained.

Colorimetric Determination of Iron

A Review of Known Methods—1

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THE estimation of iron is one of the most important analyses that have to be carried out on a wide variety of materials. The number of colorimetric methods is extensive, and some of them may have advantages over others under a particular set of conditions. An attempt has been made in the following article to review all the known methods for the colorimetric determination of iron.

Determination with Ortho-phenanthroline

The red-coloured complex formed between ferrous iron and ortho-phenanthroline was first observed by Blau,[1] the complex having the formula $[(C_{12}H_8N_2)_3Fe]^{++}$. The colour system obeys Beer's law, being independent of pH in the range 2–9, and once prepared, colour standards are stable over a period of at least six months. Fortune and Mellon[2] have conducted an intensive investigation of the method. Since iron is usually present in the ferric state it is necessary to reduce with a suitable reductant. Those examined were sodium sulphite, sodium and potassium formate, formaldehyde, hydroxylamine hydrochloride, and it was concluded that the only satisfactory one was hydroxylamine hydrochloride. Formates formed undesirable complexes as did formaldehyde and sodium sulphite, which formed a brown coloration in acid solution. Saywell and Cunningham,[3] on the other hand, state that sodium formate and sodium hypophosphite are satisfactory, but usually contaminated with iron, and they also adopted hydroxylamine hydrochloride. Pepi[4] investigated stannous chloride as reductant, but concluded that the hydroxylamine reagent was preferable, while other workers[5] have found hydroquinone to be equally satisfactory. The reagent is used at pH 4·5 with a sodium acetate buffer.

Fortune and Mellon list the following interference effects due to the presence of foreign ions, tests being carried out on a solution containing 2 p.p.m. of iron. If 500 p.p.m. of the ion did not interfere it was concluded that there was no interference.

The following do not interfere:—lithium, sodium, potassium, ammonium, arsenate, arsenite, barium, calcium, lead, magnesium, manganese, strontium. Bis-

muth and silver must be totally absent as they form precipitates with the reagent, while cadmium, zinc and mercury (II) form sparsely soluble complexes. Beryllium does not interfere in the pH range 3–5·5, and copper is non-interfering between pH 2·5–4·0. Nickel causes a change in hue, and cobalt gives a yellow colour. Tungsten and tungstates form complexes with ortho-phenanthroline.

Acetate, bromide, chlorate, chloride, citrate, iodide, nitrate, sulphate, sulphite, thiocyanate can be present up to 500 p.p.m. without causing interference. Oxalate and tartrate do not interfere above pH 6 and 3 respectively, but cyanide must be totally absent. More than 20 p.p.m. of dichromate alter the hue of solution. If nitrite is present the pH of solution must be greater than 2·5; pyrophosphate interferes seriously below pH 6, at pH 5·5 the limit being 20 p.p.m. while 50 p.p.m. of thiosulphate at pH 6 interferes, due to precipitation of colloidal sulphur, the amount precipitated being directly proportional to the time of standing.

The applicable range of the method, according to Fortune and Mellon is from 0·10–6 p.p.m. in a 1 cm. cell. The great advantage about this reagent is that it can be used in acid solution, thus preventing the precipitation of hydroxides and phosphates of many metals. Saywell and Cunningham[3] compare the reagent with mercapto-acetic acid and conclude that the advantages over the latter reagent are :—

(a) Relatively more intense colour ;
(b) Greater working sensitivity ;
(c) Much more stable colour.

They claim that aluminium and magnesium may be present in amounts up to ten times that of the iron without causing interference.

Pepi[4] has adapted the method for the determination of iron in aluminium alloys. The alloy is preferentially opened out with 1 : 1 hydrochloric acid rather than sodium hydroxide, as in the latter medium hydroxylamine hydrochloride acts as an oxidising agent, and also because the hydrochloric acid removes interfering elements such as silicon, bismuth and copper. Zinc, however, still passes into solution, but its effect can be minimised by addition of excess reagent although amounts greater than 10 p.p.m. still cause appreciable error. Pepi recommends a pH of between 2 and 3, as below pH 2 full colour is not developed, and above pH 3 hydroxylamine hydrochloride reduces only very slowly. On the other hand, if hydroquinone is employed as reductant, pH should be between 3 and 4.

Other workers[6] have used the method to estimate traces of iron in red phosphorus. The phosphorus is dissolved in a solution of bromine in carbon tetrachloride. The addition compound so formed is broken up by treatment with water, and the carbon tetrachloride is distilled off, while the hydrobromic acid is volatilised by treatment with concentrated nitric acid. The iron, now present in a solution of orthophosphoric acid, can readily be estimated by the ortho-phenanthroline method. Further work on the determination of iron in aluminium alloys in the presence of copper, nickel and zinc has been carried out by Ryan and Botham,[7] who prefer the thiocyanate method. The ortho-phenanthroline reagent is more sensitive, but suffers in that it is more expensive, and the method is time consuming. With regard to Pepi's method of solution in 1 : 1 hydrochloric acid, they state that while more practicable than solution in sodium hydroxide, it precludes the determination of manganese and copper in a composite scheme. Again, all zinc is brought into solution, and, though this is not a great disadvantage they find that some copper is also dissolved. Accordingly they favour solution of the sample in mixed acids and show that the optimum pH is 2·9–3·5. Sufficient reagent must be added to complex nickel as well as iron, and for zinc a further two equivalents should be added. Goodman[8] has adapted the ortho-phenanthroline method to the determination of iron in brass, bronze and silicon bronzes.

Moss, Mellon and Smith[9] investigated a series of ortho-phenanthroline derivatives, and found that though many develop colours, only the 5-methyl derivative possesses a stability comparable with the original substance, and so they prefer the parent substance to its derivative. They noted that cuprous salts yield a precipitate with the reagent and that copper could be estimated colorimetrically by use of a suitable solvent, but results were unsatisfactory. More recently Smith and Brandt[10] studied 5, 6-dimethyl-1, 10-phenanthroline and found that it is slightly more sensitive than the original reagent. The maximum adsorption occurs at 520 mμ and the colour is stable over 180 days. With ortho-phenanthroline the maximum adsorption is found at 510 mμ.

Determination with α, α' Dipyridyl

The use of α, α' dipyridyl for the determination of iron was first described by Hill,[11] and was developed by Kohler, Elvihjem and Hart.[12] The sensitivity is twice that obtainable with ferron, and according to Jackson[13] the pH range is much wider, being from 2·5–6·0. Moss and Mellon,[14] on the other hand, state that the range 2–9·5 is suitable. The red-purple complex, having the composition $[(C_{10}N_2H_8)_3Fe]^{++}$, shows maximum adsorption at 522 mμ, and is stable for a period of over a year.

Moss and Mellon investigated various reducing agents, namely hydroxylamine hydrochloride, titanous chloride, hydroquinone, sodium dithionite (hydrosulphite) and ascorbic acid, all of which are satisfactory. Sulphurous acid and hydrazine are unsuitable, while p-hydroxyphenylglycine has been advanced by others[15, 16] as the most suitable reducing agent. Hill favoured sodium dithionite and Jackson used hydroquinone buffered at pH 4.

Hill claims that the colour attains a maximum between pH 3·5 and 3·8, and that the colour is not influenced by the presence of other cations unless their concentration greatly exceeds that of the iron, ferric iron having no more effect than other cations. Buch[17] on the other hand states that ferrous iron alone cannot be determined in the presence of ferric iron.

Woods and Mellon[18] compared the α, α' dipyridyl and thiocyanate methods for the determination of iron, and report that the former is superior. Thiel[19] and co-workers confirm this opinion, but state that sodium hydrosulphite is unsatisfactory for the reduction process, and recommend hydroquinone and sulphite.

Scharrer[20] also prefers the α, α' dipyridyl reagent to thiocyanate, while Jackson selected α, α' dipyridyl as being superior to ferron on the grounds that the latter reagent is itself coloured, requires close control of pH, and does not obey Beer's law.

Silver, cobalt, chromium, copper, mercury (I), nickel, zinc, molybdenum and tungsten all interfere to a certain extent, and the amounts present must therefore be controlled. Jackson found that high salt concentrations

are permissible, and that although orthophosphate does not interfere, pyrophosphate suppresses full colour formation.

The 2, 2′, 2″ terpyridyl reagent was used by Cooper[21] to determine iron, the complex formed consisting of two organic molecules bound to one ferrous ion. The pH range for the reagent is 3–10, and although the reagent is extremely sensitive, it gives a highly coloured complex with cobalt. The adsorption maximum occurs at 552 mμ, and the colour is excellent for visual comparison.

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To be continued

Book Review

METAL SPECTROSCOPY

By F. Twyman, F.R.S., 569 pp., 144 illustrations, 28 tables, 2 appendices. Charles Griffin & Co., Ltd., London. 1951. 50s. net.

In 1941, Mr. Twyman published his book "The Spectrochemical Analysis of Metals and Alloys." The present book is something more than a revised edition of that earlier one since it covers, as its title suggests, a wider field of interests. For although it contains most if not all of the material published in the previous book, it has in addition chapters and sections devoted to the application of both absorption and X-ray spectroscopy to analysis.

The value of the book has been enhanced by the inclusion of chapters written by collaborators who have specialist's knowledge of the subjects about which they write. A very large part of the book is still concerned with spectrochemical methods of analysis and here, too, collaborators have served to give a note of authority to various sections, and have ensured that these sections are as up-to-date as the speed of book production in difficult times allows. The methods described are legion. They cover a wide diversity of ferrous and non-ferrous materials, and include the analysis of gases. Many of the methods are only of historical significance and are, therefore, only briefly discussed. Modern methods, however, are in most cases treated in very great detail. The excellent account of the historical development of spectroscopy has been retained in its entirety, and there are equally valuable and authoritative chapters on spectrographic light sources and electrodes. The latter deals with a variety of problems which include such matters as oxide formation during sample excitation, the preparation of electrodes, polarity, and the design of electrodes for special purposes. The chapter on sources describes the use of flames, arcs, and spark discharges. It discusses the fundamental aspects of the discharge of a condenser across a gap, and describes various devices which are incorporated in modern source units to control the discharge. It is gratifying to note that the chapter is freely illustrated throughout with circuit diagrams, and is not encumbered with photographs showing the external appearance of the units. Such photographs usually give little indication of the essential features of the unit depicted.

The basic features of prism and grating spectrographs are only briefly discussed, but there is an interesting comparison of the relative merits of the two types of instruments. G. R. Harrison of the Massachusetts Institute of Technology is quoted in support of the grating spectrograph, Mr. Twyman himself being the protagonist for the prism instrument. The situation with regard to grating has changed considerably since the publication of the earlier book in 1941, and more interest is being taken in the use of grating spectrographs for routine and control analysis. The comparison is, therefore, opportune. Unfortunately, however, no mention is made here of the more ready adaptability of the grating to direct reading, although this is the principal reason for the present interest in gratings, and may indeed be the deciding factor when a choice has to be made between purchasing either a prism or a grating spectrograph. The chapter on microphotometers and microphotometry has been expanded and brought sufficiently up-to-date to include an account of the display microphotometer. But it is noticed, by way of contrast, that when the author discusses plate response and plate calibration he continues to use the term "blackening" although "density" has now been accepted in the B.S.I. list of definitions.

The principles and practice of absorption spectroscopy are considered in a chapter entitled "The Use of Electronic Methods." The subjects of this chapter are very varied and range from an account of the Spekker Absorptiometer to a description of the Malpica and Berry electronic spark generator. The chapter might with advantage, however, have dealt solely and at greater length with absorption spectroscopy, since the other subjects could have been quite suitably discussed in other appropriate chapters. It is in fact a criticism of the book that information on some subjects is widely dispersed and appears under several chapter headings. There is also some unnecessary duplication of information. Direct reading, for example, has to be sought out in Chapters 4, 6 and 14, and the Malpica and Berry circuit is described in Chapter 6 and then again, and more appropriately, in Chapter 7. Several similar examples might be quoted. To some extent, of course, overlapping and duplication may be inevitable in a book of this kind.

It is impossible in a brief review to indicate by selection the many and diverse items with which the book deals. It is essentially a reference book, and in this respect is quite different from other books on applied spectroscopy which have come to the reviewer's notice. It is packed with information and can be said adequately to reflect the many fruitful years during which the author has (to use his own words) "been involved, implicated, entangled—whichever may be the right word" in spectroscopy.

Finally, the publishers are to be congratulated on the excellent appearance of the book, which is a pleasure to handle as well as to read.

J. H. OLDFIELD.